10 vols

Barr's Buffon.

Buffon's Natural Hiſtory.

CONTAINING

A THEORY OF THE EARTH,

A GENERAL

HISTORY OF MAN,

OF THE BRUTE CREATION, AND OF
VEGETABLES, MINERALS,
&c. &c. &c.

FROM THE FRENCH.

WITH NOTES BY THE TRANSLATOR.

IN TEN VOLUMES.

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PREFACE.

WE ſhould certainly be guilty of a groſs abſurdity if, in an age like the preſent, we were to enter into an elaborate diſcuſſion on the advantages to be derived from the ſtudy of NATURAL HISTORY; the ancients recommended it as uſeful, inſtructive, and entertaining; and the moderns have ſo far purſued and cultivated this firſt of ſciences, that it is now admitted to be the ſource of univerſal inſtruction and knowledge; where every active mind may find ſubjects to amuſe and delight, and the artiſt a never failing field to enrich his glowing imagination.

It would have been ſingular if, on ſuch a ſubject, a number of authors had not ſubmitted the produce of their obſervations and labour; many have written upon Natural Philoſophy, but the Comte de BUFFON ſtands eminently diſtinguiſhed among them; he has entered into a minute inveſtigation, and drawn numberleſs facts from unwearied obſervations far beyond any other, and this he has accompliſhed in a ſtile fully accordant with the importance of his ſubject. Ray, Linnæus, Rheamur, and other of his cotemporaries, deſerve much credit for their claſſing of animals, vegetables, &c. but it was BUFFON alone who entered into a deſcription of their nature, habits, uſes, and properties. In his Theory of the Earth he has diſplayed a wonderful ingenuity, and ſhewn the general order of Nature with a maſterly hand, although he may be ſubject to ſome objections for preferring phyſical reaſonings on general cauſes rather than allowing aught to have ariſen from ſupernatural agency, or the will of the Almighty. In this he has followed the example of all great philoſophers, who ſeem unwilling to admit that the formation of any part of the Univerſe is beyond their comprehenſion.

As the works of this Author will beſt ſpeak for themſelves, we ſhall avoid unneceſſary panegyric, hoping they will have received no material injury in the following tranſlation; we ſhall therefore, content ourſelves with obſerving, that in our plan we have followed that adopted by the Comte himſelf in a latter edition, from which he exploded his long and minute treatiſes on anatomy and menſuration; though elegant and highly finiſhed in themſelves, they appeared to us of too abſtruſe and confined a nature for general eſtimation, and which we could not have gone into without almoſt doubling the expence; a circumſtance we had to guard againſt, for the advantage of thoſe of our readers to whom that part would have been totally unintereſting.

As to this Edition we preſume it is no vain boaſt, that every exertion has been made to do juſtice to a work of ſuch acknowledged merit. In the literary part, it has been the Proprietor's chief endeavour to preſerve the ſpirit and accuracy of the Author, as far as could be done in tranſlating from one language into another; and it is with gratitude he acknowledges, that thoſe endeavours have been amply ſupported by the Engraver; for the decorative executions of MILTON will remain a laſting monument of his abilities, as long as delicacy in the arts is held in eſtimation.

BUFFON'S

NATURAL HISTORY.

THE THEORY OF THE EARTH.

NEITHER the figure of the earth, its motion, nor its external connections with the reſt of the univerſe, pertain to our preſent inveſtigation. It is the internal ſtructure of the globe, its compoſition, form, and manner of exiſtence which we purpoſe to examine. The general hiſtory of the earth ſhould doubtleſs precede that of its productions, as a neceſſary ſtudy for thoſe who wiſh to be acquainted with nature in her variety of ſhapes, and the detail of facts relative to the life and manners of animals, or to the culture and vegetation of plants, belong not, perhaps, ſo much to Natural Hiſtory, as to the general deductions drawn from the obſervations that have been made upon the different materials which compoſe the terreſtrial globe: as the heights, depths, and inequalities of its form; the motion of the ſea, the direction of mountains, the ſituation of rocks and quarries, the rapidity and effects of currents in the ocean, &c. This is the hiſtory of nature in its moſt ample extent, and theſe are the operations by which every other effect is influenced and produced. The theory of theſe effects conſtitutes what may be termed a primary ſcience, upon which the exact knowledge of particular appearances as well as terreſtrial ſubſtances entirely depends. This deſcription of ſcience may fairly be conſidered as appertaining to phyſics; but does not all phyſical knowledge, in which no ſyſtem is admitted, form part of the Hiſtory of Nature?

In a ſubject of great magnitude, whoſe relative connections are difficult to trace, and where ſome facts are but partially known, and others uncertain and obſcure, it is more eaſy to form a viſionary ſyſtem, than to eſtabliſh a rational theory; thus it is that the Theory of the Earth has only hitherto been treated in a vague and hypothetical manner; I ſhall therefore but ſlightly mention the ſingular notions of ſome authors who have written upon the ſubject.

The firſt hypotheſis I ſhall allude to, deſerves to be mentioned more for its ingenuity than its reaſonable ſolidity; it is that of an Engliſh aſtronomer, (WHISTON) verſed in the ſyſtem of NEWTON, and an enthuſiaſtic admirer of his philoſophy; convinced that every event which happens on the terreſtrial globe, depends upon the motions of the ſtars, he endeavours to prove, by the aſſiſtance of mathematical calculations, that the tail of a comet has produced every alteration the earth has ever undergone.

The next is the formation of an heterodox theologician, (BURNET) whoſe brain was ſo heated with poetical viſions, that he imagined he had ſeen the creation of the univerſe. After explaining what the earth was in its primary ſtate, when it ſprung from nothing; what changes were occaſioned by the deluge: what it has been and what it is, he then aſſumes a prophetic ſtyle, and predicts what will be its ſtate after the deſtruction of the human race.

The third comes from a writer (WOODWARD) certainly a better and more extenſive obſerver of nature than the two former, though little leſs irregular and confuſed in his ideas; he explains the principal appearances of the globe, by an immenſe abyſs in the bowels of the earth, which in his opinion is nothing more than a thin cruſt that ſerves as a covering to the fluid it encloſes.

The whole of theſe hypotheſis are raiſed on unſtable foundations; have given no light upon the ſubject, the ideas being unconnected, the facts confuſed, and the whole confounded with a mixture of phyſic and fable; and conſequently have been adopted only by thoſe who implicitly believe opinions without inveſtigation, and who, incapable of diſtinguiſhing probability, are more impreſſed with the wonders of the marvellous than the relation of truth.

What we ſhall ſay on this ſubject will doubtleſs be leſs extraordinary, and appear unimportant, if put in compariſon with the grand ſyſtems juſt mentioned, but it ſhould be remembered that it is an hiſtorian's buſineſs to deſcribe, not invent; that no ſuppoſitions ſhould be admitted upon ſubjects that depend upon facts and obſervation; that his imagination ought only to be exerciſed for the purpoſe of combining obſervations, rendering facts more general, and forming one connected whole, ſo as to preſent to the mind a diſtinct arrangement of clear ideas and probable conjectures; I ſay probable, becauſe we muſt not expect to give exact demonſtration on this ſubject, that being confined to mathematical ſciences, while our knowledge in phyſics and natural hiſtory depends ſolely upon experience, and is confined to reaſoning upon inductions.

In the hiſtory of the Earth, we ſhall therefore begin with thoſe facts that have been obtained from the experience of time, together with what we have collected by our own obſervations.

This immenſe globe exhibits upon its ſurface heights, depths, plains, ſeas, lakes, marſhes, rivers, caverns, gulphs, and volcanos; and upon the firſt view of theſe objects we cannot diſcover in their diſpoſitions either order or regularity. If we penetrate into its internal part, we ſhall there find metals, minerals, ſtones, bitumens, ſands, earths, waters, and matters of every kind, placed as it were by chance, and without the ſmalleſt apparent deſign. Examining with a more ſtrict attention, we diſcover ſunk mountains, caverns filled, rocks ſplit and broken, countries ſwallowed up, and new iſlands riſing from the ocean; we ſhall alſo perceive heavy ſubſtances placed above light ones, hard bodies ſurrounded with ſoft; in ſhort, we ſhall there find matter in every form, wet and dry, hot and cold, ſolid and brittle, mixed in ſuch a ſort of confuſion as to leave room to compare them only to a maſs of rubbiſh and the ruins of a wrecked world.

We inhabit theſe ruins however with a perfect ſecurity. The various generations of men, animals, and plants, ſucceed each other without interruption; the earth produces fully ſufficient for their ſubſiſtence; the ſea has its limits; its motions and the currents of air are regulated by fixed laws: the returns of the ſeaſons are certain and regular; the ſeverity of the winter being conſtantly ſucceeded by the beauties of the ſpring: every thing appears in order, and the earth, formerly a *chaos*, is now a tranquil and delightful abode, where all is animated, and regulated by ſuch an amazing diſplay of power and intelligence as fills us with admiration, and elevates our minds with the moſt ſublime ideas of an all-potent and wonderful Creator.

Let us not then draw any haſty concluſions upon the irregularities of the ſurface of the earth, nor the apparent diſorders in the interior parts, for we ſhall ſoon diſcover the utility, and even the neceſſity, of them; and, by conſidering them with a little attention, we ſhall, perhaps, find an order of which we had no conception, and a general connection that we could neither perceive nor comprehend, by a ſlight examination: but in fact, our knowledge on this ſubject muſt always be confined. There are many parts of the ſurface of the globe with which we are entirely unacquainted, and have but partial ideas of the bottom of the ſea, which in many places we have not been able to fathom. We can only penetrate into the coat of the earth; the greateſt caverns and the deepeſt mines do not deſcend above the eighth thouſand part of its diameter, we can therefore judge only of the external and mere ſuperficial part; we know, indeed, that bulk for bulk the earth weighs four times heavier than the ſun, and we alſo know the proportion its weight bears with other planets; but this is merely a relative eſtimation; we have no certain ſtandard nor proportion; we are ſo entirely ignorant of the real weight of the materials, that the internal part of the globe may be a void ſpace, or compoſed of matter a thouſand times heavier than gold; nor is there any method to make further diſcoveries on this ſubject; and it is with the greateſt difficulty any rational conjectures can be formed thereon.

We muſt therefore confine ourſelves to a correct examination and deſcription of the ſurface of the earth, and to thoſe trifling depths to which we have been enabled to penetrate. The firſt object which preſents itſelf is that immenſe quantity of water which covers the greateſt part of the globe; this water always occupies the loweſt ground, its ſurface always level, and conſtantly tending to equilibrium and reſt; nevertheleſs it is kept in perpetual agitation by a powerful agent, which oppoſing its natural tranquillity, impreſſes it with a regular periodical motion, alternately raiſing and depreſſing its waves, producing a vibration in the total maſs, by diſturbing the whole body to the greateſt depths. This motion we know has exiſted from the commencement of time, and will continue as long as the ſun and moon, which are the cauſes of it.

By an examination of the bottom of the ſea, we diſcover that to be fully as irregular as the ſurface of the earth; we there find hills and vallies, plains and cavities, rocks and ſoils of every kind: we there perceive that iſlands are only the ſummits of vaſt mountains, whoſe foundations are at the bottom of the ocean; we alſo find other mountains whoſe tops are nearly on a level with the ſurface of the water, and rapid currents which run contrary to the general movement: they ſometimes run in the ſame direction, at others, their motions are retrograde, but never exceeding their bounds, which appear to be as fixed and invariable as thoſe which confine the rivers of the earth. In one part we meet with tempeſtuous regions, where the winds blow with irreſiſtible fury; where the ſea and the heavens, equally agitated, join in contact with each other, are mixed and confounded in the general ſhock! in others, violent inteſtine motions, tumultuous ſwellings, water-ſpouts, and extraordinary agitations, cauſed by volcanos, whoſe mouths, though a conſiderable depth under water, yet vomit fire from the midſt of the waves, and ſend up to the clouds a thick vapour, compoſed of water, ſulphur, and bitumen. Further, we perceive dreadful gulphs or whirlpools, which ſeem to attract veſſels, merely to ſwallow them up. On the other hand, we diſcover immenſe regions, totally oppoſite in their natures, always calm and tranquil, yet equally dangerous; where the winds never exert their power, where the art of the mariner becomes uſeleſs, and where the becalmed voyager muſt remain until death relieves him from the horrors of deſpair. In concluſion, if we turn our eyes towards the northern or ſouthern extremities of the globe, we there perceive enormous flakes of ice ſeparating themſelves from the polar regions, advancing like huge mountains into the more temperate climes, where they diſſolve, and are loſt to the ſight.

Excluſive of theſe principal objects the vaſt empire of the ſea abounds with animated beings, almoſt innumerable in numbers and variety. Some of them, covered with light ſcales, move with aſtoniſhing celerity; others, loaded with thick ſhells, drag heavily along, leaving their track in the ſand; on others Nature has beſtowed fins, reſembling wings, with which they raiſe and ſupport themſelves in the air, and fly to conſiderable diſtances; while there are thoſe to whom all motion has been denied, who live and die immoveably fixed to the ſame rock: every ſpecies, however, find abundance of food in this their native element. The bottom of the ſea, and the ſhelving ſides of the various rocks, produce great abundance of plants and moſſes of different kinds; its ſoil is compoſed of ſand, gravel, rocks and ſhells; in ſome parts a fine clay, in others a ſolid earth, and in general it has a complete reſemblance to the land which we inhabit.

Let us now take a view of the earth. What prodigious differences do we find in different climates? What a variety of ſoils? What inequalities in the ſurface? But upon a minute and attentive obſervation we ſhall find the greateſt chain of mountains are nearer the equator than the poles; that in the Old Continent their direction is more from the eaſt to weſt than from the north to ſouth; and that, on the contrary, in the New World they extend more from north to ſouth than from eaſt to weſt; but what is ſtill more remarkable, the form and direction of thoſe mountains, whoſe appearance is ſo very irregular, correſpond ſo preciſely, that the prominent angles of one mountain are always oppoſite to the concave angles of the neighbouring mountain, and are of equal dimenſions, whether they are ſeparated by a ſmall valley or an extenſive plain. I have alſo obſerved that oppoſite hills are nearly of the ſame height, and that, in general, mountains occupy the middle of continents, iſlands, and promontories, which they divide by the greateſt lengths.

In following the courſes of the principal rivers I have likewiſe found that they are almoſt always perpendicular with thoſe of the ſea into which they empty themſelves; and that in the greateſt part of their courſes they proceed nearly in the direction of the mountains from which they derive their ſource.

The ſea ſhores are generally bounded with rocks, marble, and other hard ſtones, or by earth and ſand which has accumulated by the waters from the ſea, or been brought down by the rivers; and I obſerve that oppoſite coaſts, ſeparated only by an arm of the ſea, are compoſed of ſimilar materials, and the beds of the earth are exactly the ſame. Volcanos I find exiſt only in the higheſt mountains, that many of them are entirely extinct; that ſome are connected with others by ſubterraneous paſſages, and that their exploſions frequently happen at one and the ſame time. There are ſimilar correſpondences between certain lakes and neighbouring ſeas; ſome rivers ſuddenly diſappear, and ſeem to precipitate themſelves into the earth. We alſo find internal, or mediterranean ſeas, conſtantly receiving an enormous quantity of water from a number of rivers without ever extending their bounds, moſt probably diſcharging by ſubterraneous paſſages all their ſuperfluous ſupplies. Lands which have been long inhabited are eaſily diſtinguiſhed from new countries, where the ſoil appears in a rude ſtate, where the rivers are full of cataracts, where the earth is either overflowed with water, or parched up with drought, and where every ſpot, upon which a tree will grow, is covered with uncultivated woods.

Purſuing our examination in a more extenſive view, we find that the upper ſtrata that ſurrounds the globe, is univerſally the ſame. That this ſubſtance, which ſerves for the growth and nouriſhment of animals and vegetables, is nothing but a compoſition of decayed animal and vegetable bodies, reduced into ſuch ſmall particles that their former organization is not diſtinguiſhable; or penetrating a little further we find the real earth, beds of ſand, limeſtone, argol, ſhells, marble, gravel, chalk, &c. Theſe beds are always parallel to each other, and of the ſame thickneſs throughout their whole extent. In neighbouring hills beds of the ſame materials are invariably found upon the ſame levels, though the hills are ſeparated by deep and extenſive intervals. All beds of earth, even the moſt ſolid ſtrata, as rocks, quarries of marble, &c. are uniformly divided by perpendicular fiſſures; it is the ſame in the largeſt as well as ſmalleſt depths, and appears a rule which nature invariably purſues.

In the very bowels of the earth, on the tops of mountains, and even the moſt remote parts from the ſea, ſhells, ſkeletons of fiſhes, marine plants, &c. are frequently found, and theſe ſhells, fiſhes and plants, are exactly ſimilar to thoſe which exiſt in the ocean. There are a prodigious quantity of petrified ſhells to be met with in an infinity of places, not only incloſed in rocks, maſſes of marble, limeſtone, as well as in earths and clays, but are actually incorporated and filled with the very ſubſtance which ſurrounds them. In ſhort, I find myſelf convinced, by repeated obſervations, that marbles, ſtones, chalks, marles, clay, ſand, and almoſt all terreſtrial ſubſtances, wherever they may be placed, are filled with ſhells and other ſubſtances, the productions of the ſea.

Theſe facts being enumerated, let us now ſee what reaſonable concluſions are to be drawn from them.

The changes and alterations which have happened to the earth in the ſpace of the laſt two or three thouſand years are very inconſiderable, indeed, when compared with thoſe important revolutions which muſt have taken place in thoſe ages which immediately followed the creation; for as all terreſtrial ſubſtances could only acquire ſolidity by the continued action of gravity, it would be eaſy to demonſtrate, that the ſurface of the earth was much ſofter at firſt than it is at preſent, and conſequently the ſame cauſes which now produce but ſlight and almoſt imperceptible changes, during many ages, would then effect great revolutions in a very ſhort ſpace. It appears to be a certain fact, that the earth which we now inhabit, and even the tops of the higheſt mountains, were formerly covered with the ſea, for ſhells and other marine productions are frequently found in almoſt every part; it appears alſo that the water remained a conſiderable time on the ſurface of the earth, ſince in many places there have been diſcovered ſuch prodigious banks of ſhells, that it is impoſſible ſo great a multitude of animals could exiſt at the ſame time: this fact ſeems likewiſe to prove, that although the materials which compoſe the ſurface of the earth were then in a ſtate of ſoftneſs, that rendered them eaſy to be diſunited, moved and tranſported by the waters, yet that theſe removals were not made at once; they muſt indeed have been ſucceſſive, gradual, and by degrees, becauſe theſe kind of ſea-productions are frequently met with more than a thouſand feet below the ſurface, and ſuch a conſiderable thickneſs of earth and ſtone could not have accumulated but by the length of time. If we were to ſuppoſe that at the Deluge all the ſhell-fiſh were raiſed from the bottom of the ſea, and tranſported over all the earth; beſides the difficulty of eſtabliſhing this ſuppoſition, it is evident, that as we find ſhells incorporated in marble and in the rocks of the higheſt mountains, we muſt likewiſe ſuppoſe that all theſe marbles and rocks were formed at the ſame time, and that too at the very inſtant of the Deluge; and beſides, that previous to this great revolution there were neither mountains, marble, nor rocks, nor clays, nor matters of any kind ſimilar to thoſe we are at preſent acquainted with, as they almoſt all contain ſhells and other productions of the ſea. Beſides, at the time of the Deluge, the earth muſt have acquired a conſiderable degree of ſolidity, from the action of gravity for more than ſixteen centuries, and conſequently it does not appear poſſible that the waters, during the ſhort time the Deluge laſted, ſhould have overturned and diſſolved its ſurface to the greateſt depths we have ſince been enabled to penetrate.

But without dwelling longer on this point, which ſhall hereafter be more amply diſcuſſed, I ſhall confine myſelf to well-known obſervations and eſtabliſhed facts. There is no doubt but that the waters of the ſea at ſome period covered and remained for ages upon that part of the globe which is now known to be dry land; and conſequently the whole continents of Aſia, Europe, Africa, and America, were then the bottom of an ocean abounding with ſimilar productions to thoſe which the ſea at preſent contains: it is equally certain that the different ſtrata which compoſe the earth are parallel and horizontal, and it is evident their being in this ſituation is the operation of the waters which have collected and accumulated by degrees the different materials, and given them the ſame poſition as the water itſelf always aſſumes. We obſerve that the poſition of ſtrata is almoſt univerſally horizontal: in plains it is exactly ſo, and it is only in the mountains that they are inclined to the horizon, from their having been originally formed by a ſediment depoſited upon an inclined baſe. Now I inſiſt that theſe ſtrata muſt have been formed by degrees, and not all at once, by any revolution whatever, becauſe ſtrata, compoſed of heavy materials, are very frequently found placed above light ones, which could not be, if, as ſome authors aſſert, the whole had been mixed with the waters at the time of the Deluge, and afterwards precipitated; in that caſe every thing muſt have had a very different appearance to that which now exiſts. The heavieſt bodies would have deſcended firſt, and each particular ſtratum would have been arranged according to its weight and ſpecific gravity, and we ſhould not ſee ſolid rocks or metals placed above light ſand any more than clay under coal.

We ſhould alſo pay attention to another circumſtance; it confirms what we have ſaid on the formation of the ſtrata; no other cauſe than the motions and ſediments of water could poſſibly produce ſo regular a poſition of it, for the higheſt mountains are compoſed of parallel ſtrata as well as the loweſt plains, and therefore we cannot attribute the origin and formation of mountains to the ſhocks of earthquakes, or eruptions of volcanos. The ſmall eminences which are ſometimes raiſed by volcanos, or convulſive motions of the earth, are not by any means compoſed of parallel ſtrata, they are a mere diſordered heap of matters thrown confuſedly together; but the horizontal and parallel poſition of the ſtrata muſt neceſſarily proceed from the operations of a conſtant cauſe and motion, always regulated and directed in the ſame uniform manner.

From repeated obſervations, and theſe incontrovertible facts, we are convinced that the dry part of the globe, which is now habitable, has remained for a long time under the waters of the ſea, and conſequently this earth underwent the ſame fluctuations and changes which the bottom of the ocean is at preſent actually undergoing. To diſcover therefore what formerly paſſed on the earth, let us examine what now paſſes at the bottom of the ſea, and from thence we ſhall ſoon be enabled to draw rational concluſions with regard to the external form and internal compoſition of that which we inhabit.

From the creation the ſea has conſtantly been ſubject to a regular flux and reflux: this motion, which raiſes and falls the waters twice in every twenty-four hours, is principally occaſioned by the action of the moon, and is much greater under the equator than in any other climates. The earth performs a rapid motion on its axis, and conſequently has a centrifugal force, which is alſo the greateſt at the equator; this latter, independent of actual obſervation, proves that the earth is not perfectly ſpherical, but that it muſt be more elevated under the equator than at the poles.

From theſe combined cauſes, the ebbing and flowing of the tides, and the motion of the earth, we may fairly conclude, that although the earth was a perfect ſphere in its original form, yet its diurnal motion, together with the conſtant flux and reflux of the ſea, muſt, by degrees, in the courſe of time, have raiſed the equatorial parts, by carrying mud, earth, ſand, ſhells, &c. from other climes, and there depoſiting of them. Agreeable to this idea the greateſt irregularities muſt be found, and, in fact, are found near the equator. Beſides, as this motion of the tides is made by diurnal alternatives, and been repeated, without interruption, from the commencement of time, is it not natural to imagine, that each time the tide flows the water carries a ſmall quantity of matter from one place to another, which may fall to the bottom like a ſediment, and form thoſe parallel and horizontal ſtrata which are every where to be met with? for the whole motion of the water, in the flux and reflux, being horizontal, the matters carried away with them will naturally be depoſited in the ſame parallel direction.

But to this it may be ſaid, that as the flux and reflux of the waters are equal and regularly ſucceed, two motions would counterpoiſe each other, and the matters brought by the flux would be returned by the reflux, and of courſe this cauſe for the formation of the ſtrata muſt be chimerical; that the bottom of the ſea could not experience any material alteration by two uniform motions, wherein the effects of the one would be regularly deſtroyed by the other; much leſs could they change the original form by the production of heights and inequalities.

To which it may be anſwered, that the alternate motions of the waters are not equal, the ſea having a conſtant motion from the eaſt to the weſt; beſides, the agitations, cauſed by the winds, oppoſes and prevents the equality of the tides. It will alſo be admitted, that by every motion of which the ſea is ſuſceptible, particles of earth and other matters will be carried from one place and depoſited in another; and theſe collections will neceſſarily aſſume the form of horizontal and parallel ſtrata, from the various combinations of the motions of the ſea always tending to move the earth, and to level theſe materials wherever they fall in the form of a ſediment. But this objection is eaſily obviated by the well-known fact, that upon all coaſts, bordering the ſea, where the ebbing and flowing of the tide is obſerved, the flux conſtantly brings in a number of things which the reflux does not carry back. There are many places upon which the ſea inſenſibly gains and gradually covers over, while there are others from which it recedes, narrowing as it were its limits, by depoſiting earth, ſands, ſhells, &c. which naturally take an horizontal poſition; theſe matters accumulate by degrees in the courſe of time, and being raiſed to a certain point gradually exclude the water, and ſo become part of the dry land for ever after.

But not to leave any doubt upon this important point, let us ſtrictly examine into the poſſibility of a mountain's being formed at the bottom of the ſea by the motions and ſediments of the waters. It is certain that on a coaſt which the ſea beats with violence during the agitation of its flow, that every wave muſt carry off ſome part of the earth; for wherever the ſea is bounded by rocks, it is a plain fact that the water by degrees wears away thoſe rocks, and conſequently carries away ſmall particles every time the waves retire; theſe particles of earth and ſtone will neceſſarily be tranſported to ſome diſtance, and being arrived where the agitation of the water is abated, and left to their own weight, they precipitate to the bottom in form of a ſediment, and there form a firſt ſtratum either horizontal or inclined according to the poſition of the ſurface upon which they fall; this will ſhortly be covered by a ſimilar ſtratum produced by the ſame cauſe, and thus will a conſiderable quantity of matter be almoſt inſenſibly collected together, and the ſtrata of which will be placed parallel to each other.

This maſs will continue to increaſe by new ſediments, and by gradually accumulating, in the courſe of time become a mountain at the bottom of the ſea, exactly ſimilar to thoſe we ſee on dry land, both as to outward form and internal compoſition. If there happen to be ſhells in this part of the ſea, where we have ſuppoſed this depoſit to be made, they will be filled and covered with the ſediment, and incorporated in the depoſited matter, making a part of the whole maſs, and they will be found ſituated in the parts of the mountain according to the time they had been there depoſited; thoſe that lay at the bottom, previous to the formation of the firſt ſtratum, will be found in the loweſt, and ſo according to the time of their being depoſited, the lateſt in the moſt elevated parts.

So likewiſe, when the bottom of the ſea, at particular places, is troubled by the agitation of the water, there will neceſſarily enſue, in the ſame manner, a removal of earth, ſhells, and other matters, from the troubled to other parts; for we are aſſured by all divers, that at the greateſt depths they deſcend, i. e. 20 fathoms, the bottom of the ſea is ſo troubled by the agitation of the waters, that the mud and ſhells are carried to conſiderable diſtances, conſequently tranſportations of this kind are made in every part of the ſea, and this matter falling muſt form eminences, compoſed like our mountains, and in every reſpect ſimilar; therefore the flux and reflux, by the winds, the currents, and all the motions of the water, muſt inevitably create inequalities at the bottom of the ſea.

Nor muſt we imagine that theſe matters cannot be tranſported to great diſtances, becauſe we daily ſee grain, and other productions of the Eaſt and Weſt Indies, arriving on our own coaſts *. It is true theſe bodies are ſpecifically lighter than water, whereas the ſubſtances of which we have been ſpeaking are ſpecifically heavier; but, however, being reduced to an impalpable powder, they may be ſuſtained a long time in the water ſo as to be conveyed to conſiderable diſtances.

It has been ſuppoſed that the ſea is not troubled at the bottom, eſpecially if it is very

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* Particularly Scotland and Ireland.

deep, by the agitations produced by the winds and tides; but it ſhould be recollected that the whole maſs, however deep, is put in motion by the tides, and that in a liquid globe this motion would be communicated to the very centre; that the power which produces the flux and reflux is a penetrating force, which acts proportionably upon every particle of its maſs, ſo that we can determine by calculation the quantity of its force at different depths; but, in ſhort, this point is ſo certain, that it cannot be conteſted but by refuſing the evidence of reaſon.

Therefore, we cannot poſſibly have the leaſt doubt that the tides, the winds, and every other cauſe which agitates the ſea, muſt produce eminences and inequalities at the bottom, and thoſe heights muſt ever be compoſed of horizontal or equally inclined ſtrata. Theſe eminences will gradually encreaſe until they become hills, which will riſe in ſituations ſimilar to the waves that produce them; and if there is a long extent of ſoil, they will continue to augment by degrees; ſo that in courſe of time they will form a vaſt chain of mountains. Being formed into mountains, they become an obſtacle to and interrupt the common motion of the ſea, producing at the ſame time other motions, which are generally called currents. Between two neighbouring heights at the bottom of the ſea a current will neceſſarily be formed, which will follow their common direction, and, like a river, form a channel, whoſe angles will be alternatively oppoſite during the whole extent of its courſe. Theſe heights will be continually increaſing, being ſubject only to the motion of the flux, for the waters during the flow will leave the common ſediment upon their ridges; and thoſe waters which are impelled by the current will force along with them, to great diſtances, thoſe matters which would be depoſited between both, at the ſame time hollowing out a valley with correſponding angles at their foundation. By the effects of theſe motions and ſediments the bottom of the ſea, although originally ſmooth, muſt become unequal, and abounding with hills and chains of mountains, as we find it at preſent. The ſoft materials of which the eminences are originally compoſed will harden by degrees with their own weight; ſome forming parts, purely angular, produce hills of clay; others, conſiſting of ſandy and cryſtalline particles, compoſe thoſe enormous maſſes of rock and flint from whence cryſtal and other precious ſtones are extracted; thoſe formed with ſtony particles, mixed with ſhells, form thoſe of lime-ſtone and marble, wherein we daily meet with ſhells incorporated; and others, compounded of matter more ſhelly, united with pure earth, compoſe all our beds of marle and chalk. All theſe ſubſtances are placed in regular beds, and all contain heterogeneous matter; marine productions are found among them in abundance, and nearly according to the relation of their ſpecific weights; the lighteſt ſhells in chalk, and the heavieſt in clay and lime-ſtone; theſe ſhells are invariably filled with the matter in which they have been incloſed, whether ſtones or earth; an inconteſtible proof that they have been tranſported with the matter that fills and ſurrounds them, and that this matter was at that time in an impalpable powder. In ſhort, all thoſe ſubſtances whoſe horizontal ſituations have been eſtabliſhed by the level of the waters of the ſea, will conſtantly preſerve their original poſition.

But here it may be obſerved, that moſt hills, whoſe ſummits conſiſt of ſolid rocks, ſtone, or marble, are formed upon ſmall eminences of much lighter materials, ſuch for inſtance as clay, or ſtrata of ſand, which we commonly find extended over the neighbouring plains; upon which it may be aſked, how, if the foregoing theory be juſt, this ſeemingly contradictory arrangement happens? To me this phenomenon appears to be very eaſy and naturally explained. The water at firſt acts upon the upper ſtratum of coaſts, or bottom of the ſea, which commonly conſiſts of clay or ſand, and having tranſported this, and depoſited the ſediment, it of courſe compoſes ſmall eminences, which form a baſe for the more heavy particles to reſt upon. Having removed the lighter ſubſtances, it operates upon the more heavy, and by conſtant attrition reduces them to an impalpable powder; which it conveys to the ſame ſpot, and where, being depoſed, theſe ſtony particles, in the courſe of time, form thoſe ſolid rocks and quarries which we now find upon the tops of hills and mountains. It is not unlikely that as theſe particles are much heavier than ſand or clay, that they were formerly a conſiderable depth under a ſtrata of that kind, and now owe their high ſituations to having been laſt raiſed up and tranſported by the motion of the water.

To confirm what we here aſſert, let us more cloſely inveſtigate the ſituation of thoſe materials which compoſe the ſuperficial outer part of the globe, indeed the only part with which we have any knowledge. The different beds of ſtrata in ſtone quarries are almoſt all horizontal, or regularly inclined; thoſe whoſe foundations are on clays or other ſolid matters are clearly horizontal, eſpecially in plains. The quarries wherein we find flint, or browniſh grey free-ſtone, in detached portions, have a leſs regular poſition, but even in thoſe the uniformity of nature plainly appears, for the horizontal or regularly inclined ſtrata are apparent in quarries where theſe ſtones are found in great maſſes. This poſition is univerſal, except in quarries where flint and brown free-ſtone are found in ſmall detached portions, the formation of which we ſhall prove to have been poſterior to thoſe we have juſt been treating of; for granate, vitrifiable ſand, argol, marble, calcareous ſtone, chalk, and marles, are always depoſited in parallel ſtrata, horizontally or equally inclined; the original formation of theſe are eaſily diſcovered, for the ſtrata are exactly horizontal and very thin, and are arranged above each other like the leaves of a book. Beds of ſand, ſoft and hard clay, chalk, and ſhells, are alſo either horizontal or regularly inclined. Strata of every kind preſerves the ſame thickneſs throughout its whole extent, which often occupies the ſpace of many miles, and might be traced ſtill farther by cloſe and exact obſervations. In a word, the materials of the globe, as far as mankind have been enabled to penetrate, are arranged in an uniform poſition, and are exactly ſimilar.

The ſtrata of ſand and gravel which have been waſhed down from mountains muſt in ſome meaſure be excepted; in vallies they are ſometimes of a conſiderable extent, and are generally placed under the firſt ſtrata of the earth; in plains, they are as even as the moſt ancient and interior ſtrata, but near the bottom and upon the ridges of hills they are inclined, and follow the inclination of the ground upon which they have flowed. Theſe being formed by rivers and rivulets, which are conſtantly in vallies changing their beds, and dragging theſe ſands and gravel with them, they are of courſe very numerous. A ſmall rivulet flowing from the neighbouring heights, in the courſe of time, will be ſufficient to cover a very ſpacious valley with a ſtrata of ſand and gravel, and I have often obſerved in hilly countries, whoſe baſe, as well as the upper ſtratum, was hard clay, that above the ſource of the rivulet the clay is found immediately under the vegetable ſoil, and below it there is the thickneſs of a foot of ſand upon the clay, and which extends itſelf to a conſiderable diſtance. Theſe ſtrata formed by rivers are not very ancient, and are eaſily diſcovered by the inequality of their thickneſs, which is conſtantly varying, while the ancient ſtrata preſerves the ſame dimenſions throughout; they are alſo to be known by the matter itſelf, which bears evident marks of having been ſmoothed and rounded by the motions of the water. The ſame may be ſaid of the turf and periſhed vegetables which are found below the firſt ſtratum of earth in marſhy grounds; they cannot be conſidered as ancient, but entirely produced by ſucceſſive heaps of decayed trees and other plants. Nor are the ſtrata of ſlime and mud, which are found in many countries, to be conſidered as ancient productions, having been formed by ſtagnated waters or inundations of rivers, and are neither ſo horizontal, nor equally inclined, as the ſtrata anciently produced by the regular motions of the ſea. In the ſtrata formed by rivers we conſtantly meet with river, but ſcarcely ever ſea ſhells, and the few that are found are broken and irregularly placed; whereas in the ancient ſtrata there are no river ſhells; the ſea ſhells are in great quantities, well preſerved, and all placed in the ſame manner, having been tranſported at the ſame time and by the ſame cauſe. How are we to account for this aſtoniſhing regularity? Inſtead of regular ſtrata why do we not meet with the matters that compoſe the earth jumbled together, without any kind of order? Why are not rocks, marbles, clays, marles, &c. variouſly diſperſed, or joined by irregular or vertical ſtrata? Why are not the heavieſt bodies uniformly found placed beneath the lighteſt? It is eaſy to perceive that this uniformity of nature, this organization of earth, this connection of different materials, by parallel ſtrata, without reſpect to their weights, could only be produced by a cauſe as powerful and conſtant as the motion of the ſea, whether occaſioned by the regular winds, or by that of the flux and reflux, &c.

Theſe cauſes act with greater force under the equator than in other climates, for there the winds are more regular and the tides run higher; the moſt extenſive chains of mountains are alſo near the equator. The mountains of Africa and Peru are the higheſt known, they frequently extend themſelves through whole provinces, and ſtretch to conſiderable diſtances under the ocean. The mountains of Europe and Aſia, which extend from Spain to China, are not ſo high as thoſe of South America and Africa. The mountains of the North, according to the relation of travellers, are only hills in compariſon with thoſe of the Southern countries. Beſides, there are very few iſlands in the Northern Seas, whereas in the torrid zone they are almoſt innumerable, and as iſlands are only the ſummits of mountains, it is evident that the ſurface of the earth has many more inequalities towards the equator than in the northerly climes.

It is therefore evident that the prodigious chain of mountains which run from the Weſt to the Eaſt in the old continent, and from the North to the South in the new, muſt have been produced by the general motion of the tides; but the origin of all the inferior mountains muſt be attributed to the particular motions of currents, occaſioned by the winds and other irregular agitations of the ſea: they may probably have been produced by a combination of all thoſe motions, which muſt be capable of infinite variations, ſince the winds and different poſitions of iſlands and coaſts change the regular courſe of the tides, and compel them to flow in every poſſible direction: it is, therefore, not in the leaſt aſtoniſhing that we ſhould ſee conſiderable eminences, whoſe courſes have no determined direction. But it is ſufficient for our preſent purpoſe to have demonſtrated that mountains are not the produce of earthquakes, or other accidental cauſes, but that they are the effects reſulting from the general order of nature, both as to their organization, and the poſition of the materials of which they are compoſed.

But how has it happened that this earth which we and our anceſtors have inhabited for ages, which, from time immemorial, has been an immenſe continent, dry and removed from the reach of the waters, ſhould, if formerly the bottom of the ocean, be actually larger than all the waters, and raiſed to ſuch a height as to be diſtinctly ſeparated from them? Having remained ſo long on the earth, why have the waters now abandoned it? What accident, what cauſe could produce ſo great a change? Is it poſſible to conceive one poſſeſſed of ſufficient power to produce ſuch an amazing effect?

Theſe queſtions are difficult to be reſolved, but as the facts are certain and incontrovertible, the exact manner in which they happened may remain unknown, without prejudicing the concluſions that may be drawn from them; nevertheleſs, by a little reflection, we ſhall find at leaſt plauſible reaſons for theſe changes. We daily obſerve the ſea gaining ground on ſome coaſts and loſing it on others; we know that the ocean has a continued regular motion from Eaſt to Weſt; that it makes loud and violent efforts againſt the low lands and rocks which confine it; that there are whole provinces which human induſtry can hardly ſecure from the rage of the ſea; that there are inſtances of iſlands riſing above, and others being ſunk under the waters. Hiſtory ſpeaks of much greater deluges and inundations. Ought not this to incline us to believe that the ſurface of the earth has undergone great revolutions, and that the ſea may have quitted the greateſt part of the earth which it formerly covered? Let us but ſuppoſe that the old and new worlds were formerly but one continent, and that the

Atlantis of Plato, was ſunk by a violent earthquake; the natural conſequence would be, that the ſea would neceſſarily have flowed in from all ſides, and formed what is now called the Atlantic Ocean, leaving vaſt continents dry, and poſſibly thoſe which we now inhabit. This revolution, therefore, might be made of a ſudden by the opening of ſome vaſt cavern in the interior part of the globe, which an univerſal deluge muſt inevitably ſucceed; or poſſibly this change was not effected at once but required a length of time, which I am rather inclined to think; however theſe conjectures may be, it is certain the revolution has occurred, and in my opinion very naturally, for to judge of the future, as well as the paſt, we muſt carefully attend to what daily happens before our eyes. It is a fact clearly eſtabliſhed by repeated obſervations of travellers, that the ocean has a conſtant motion from the Eaſt to Weſt; this motion, like the trade winds, is not only felt between the tropics but alſo throughout the temperate climates, and as near the poles as navigators have gone; of courſe the Pacific Ocean makes a continual effort againſt the coaſts of Tartary, China, and India; the Indian Ocean acts againſt the eaſt coaſt of Africa, and the Atlantic in like manner againſt all the eaſtern coaſts of America; therefore the ſea muſt have always and ſtill continues to gain land on the eaſt and loſe it on the weſt; and this alone is ſufficient to prove the poſſibility of the change of earth into ſea, and ſea into land. If, in fact, ſuch are the effects of the ſea's motion from eaſt to weſt, may we not very reaſonably ſuppoſe that Aſia and the eaſtern continent is the oldeſt country in the world, and that Europe and part of Africa, eſpecially the weſtern coaſts of theſe continents, as Great Britain, France, Spain, Muratania, &c. are of a more modern date? Both hiſtory and phyſics agree in confirming this conjecture.

There are, however, many other cauſes which concur with the continual motion of the ſea from eaſt to weſt, in producing theſe effects.

In many places there are lands lower than the level of the ſea, and which are only defended from it by an iſthmus of rocks, or by banks and dykes of ſtill weaker materials; theſe barriers muſt gradually be deſtroyed by the conſtant action of the ſea, when the lands will be overflowed, and conſtantly make part of the ocean. Beſides, are not mountains daily decreaſing by the rains which looſens the earth, and carries it down into the vallies? It is alſo well known that floods waſh the earth from the plains and high grounds into the ſmall brooks and rivers, who in their turn convey it into the ſea. By theſe means the bottom of the ſea is filling up by degrees, the ſurface of the earth lowering to a level, and nothing but time is neceſſary for the ſea's ſucceſſively changing places with the earth.

I ſpeak not here of theſe remote cauſes which ſtand above our comprehenſion; of thoſe convulſions of nature, whoſe leaſt effects would be fatal to the world; the near approach of a comet, the abſence of the moon, the introduction of a new planet, &c. are ſuppoſitions on which it is eaſy to give ſcope to the imagination. Such cauſes would produce any effects we choſe, and from a ſingle hypotheſis of this nature, a thouſand phyſical romances might be drawn, and which the authors might term, *The Theory of the Earth*. As hiſtorians we reject theſe vain ſpeculations; they are mere poſſibilities which ſuppoſe the deſtruction of the univerſe, in which our globe, like a particle of forſaken matter, eſcapes our obſervation, and is no longer an object worthy regard; but to preſerve conſiſtency, we muſt take the earth as it is, cloſely obſerving every part, and by inductions judge of the future from what exiſts at preſent; in other reſpects we ought not to be affected by cauſes which ſeldom happen, and whoſe effects are always ſudden and violent; they do not occur in the common courſe of nature; but effects which are daily repeated, motions which ſucceed each other without interruption, and operations that are conſtant, ought alone to be the ground of our reaſoning.

We will add ſome examples thereto; we will combine particular effects with general cauſes, and give a detail of facts which will render apparent, and explain the different changes that the earth has undergone, whether by the eruption of the ſea upon the land, or by retiring from that which it had formerly covered.

The greateſt eruption was certainly that which gave riſe to the Mediterranean ſea. The ocean flows through a narrow channel between two promontories with great rapidity, and then forms a vaſt ſea, which, without including the Black ſea, is about ſeven times larger than the kingdom of France. Its motion through the ſtraits of Gibraltar is contrary to all other ſtraits, for the general motion of the ſea is from eaſt to weſt, but in that alone it is from the weſt to the eaſt, which proves that the Mediterranean ſea is not an ancient gulph, but that it has been formed by an eruption, produced by ſome accidental cauſe; as an earthquake which might ſwallow up the earth in the ſtrait, or by a violent effort of the ocean, cauſed by the wind, which might have forced its way through the banks between the promontories of Gibraltar and Ceuta. This opinion is authoriſed by the teſtimony of the ancients, who declare in their writings, that the Mediterranean ſea did not formerly exiſt; and confirmed by natural hiſtory and obſervations made on the oppoſite coaſts of Spain, where ſimilar beds of ſtones and earth are found upon the ſame levels, in like manner as they are in two mountains ſeparated by a ſmall valley.

The ocean having forced this paſſage, it ran at firſt through the ſtraits with much greater rapidity than at preſent, and overflowed the continent that joined Europe to Africa. The waters covered all the low countries, of which we can only now perceive the tops of ſome of the conſiderable mountains, ſuch as parts of Italy, the iſlands of Sicily, Malta, Corſica, Sardinia, Cyprus, Rhodes, and thoſe of the Archipelago.

In this eruption I have not included the Black ſea, becauſe the quantity of water it receives from the Danube, Nieper, Don, and various other rivers, is fully ſufficient to form and ſupport it; and beſides it flows with great rapidity through the Boſphorous into the Mediterranean. It might alſo be preſumed that the Black and Caſpian ſeas were formerly only two large lakes, joined by a narrow communication, or by a moraſs, or ſmall lake, which united the Don and the Wolga near Tria, where theſe two rivers flow near each other; nor is it improbable that theſe two ſeas or lakes, were then of much greater extent, for the immenſe rivers which fall into the Black and Caſpian ſeas may have brought down a ſufficient quantity of earth to ſhut up the communication and form that neck of land by which they now are ſeparated; for we know great rivers, in the courſe of time, fill up ſeas and form new land, as the province at the mouth of the Yellow river in China; Louiſania at the mouth of the Miſſiſſippi, and the northern part of Egypt, which owes its exiſtence to the inundations of the Nile; the rapidity of which brings down ſuch quantities of earth from the internal parts of Africa, as to depoſit on the ſhores, during the inundations, a body of ſlime and mud, of more than fifty feet in depth. The province of the Yellow river and Louiſania, have, in like manner, been formed by the ſoil from the rivers.

The Caſpian ſea is actually a real lake; having no communication with other ſeas, not even with the lake Aral, which ſeems to have been a part of it, being only ſeparated from it by a large track of ſand, in which neither rivers nor canals for communicating the waters have as yet been found. This ſea, therefore, has no external communication with any other; and I do not know that we are authoriſed to ſuſpect that it has an internal one with the Black ſea, or with the Gulph of Perſia. It is true the Caſpian ſea receives the Wolga and many other rivers, which ſeem to furniſh it with more water than is loſt by evaporation; but independent of the difficulty of ſuch calculation, if it had a communication with any other ſea, a conſtant and rapid current towards the opening would have marked its courſe, but I never heard of any ſuch diſcovery being made; travellers, of the beſt credit, affirm to the contrary, and conſequently the Caſpian ſea muſt loſe by evaporation juſt as much water as it receives from the Wolga and other rivers.

Nor is it any improbable conjecture that the Black ſea will at ſome period be ſeparated from the Mediterranean; and that the Boſphorous will be ſhut up, whenever the great rivers ſhall have accumulated a ſufficient quantity of earth to anſwer that effect; this may be the caſe in the courſe of time by the ſucceſſive diminution of waters in rivers, in proportion as the mountains from whence they draw their ſources are lowered by the rains, and thoſe other cauſes we have juſt alluded to.

The Caſpian and Black ſeas muſt therefore be looked upon rather as lakes than gulphs of the ocean, for they reſemble other lakes which receive a number of rivers without any apparent outlet, ſuch as the Dead ſea, many lakes in Africa and other places. Theſe two ſeas are not near ſo ſalt as the Mediterranean or the ocean; and all voyagers affirm that the navigation in the Black and Caſpian ſeas, upon account of its ſhallowneſs and quantity of rocks and quickſands, is ſo extremely dangerous, that only ſmall veſſels can be uſed with ſafety; which farther proves they muſt not be looked upon as gulphs of the ocean, but as immenſe bodies of water collected from great rivers.

A conſiderable eruption of the ſea would doubtleſs take place upon the earth, if the iſthmus which ſeparates Africa from Aſia was divided, as the Kings of Egypt, and afterwards the Caliphs projected; and I do not know that the communication between the Red ſea and Mediterranean is ſufficiently eſtabliſhed, as the former muſt be higher than the latter. The Red ſea is a narrow branch of the ocean, and does not receive into it a ſingle river on the ſide of Egypt, and very few on the oppoſite coaſt; it will not therefore be ſubject to diminution, like thoſe ſeas and lakes which are conſtantly receiving ſlime and ſand from thoſe rivers that flow into them. The ocean ſupplies the Red ſea with all its water, and the motion of the tides is very evident in it, of courſe it muſt be affected by every movement of the ocean. But the Mediterranean muſt be lower than the ocean, becauſe the current paſſes with great rapidity through the ſtraits; beſides, it receives the Nile, which flows parallel to the weſt coaſt of the Red ſea, and which divides Egypt, a very low country; from all which it appears probable, that the Red ſea is higher than the Mediterranean, and that if the iſthmus of Suez was cut through there would be a great inundation, and a conſiderable augmentation of the Mediterranean would enſue; at leaſt if the waters were not reſtrained by dykes and ſluices placed at proper diſtances, and which was moſt likely the caſe if the ancient canal of communication ever had exiſtence.

Without dwelling longer upon conjectures, which, although well founded, may appear hazardous and raſh, we ſhall give ſome recent and certain examples of the change of the ſea into land, and the land into ſea. At Venice the bottom of the Adriatic is daily riſing, and if great care had not been taken to clean and empty the canals, the whole would long ſince have formed part of the continent; the ſame may be ſaid of moſt ports, bays, and mouths of rivers. In Holland the bottom of the ſea has riſen in many places; the gulph of Zuyderzee, and the ſtrait of the Texel cannot receive ſuch large veſſels as formerly. At the mouth of all rivers we find ſmall iſlands, and banks of ſand and earth brought down by the waters, and it is certain the ſea will be filled up in every part where great rivers empty themſelves. The Rhine is loſt in the ſands which itſelf accumulated. The Danube and the Nile, and all great rivers, after bringing down much ſand and earth, no longer comes to the ſea by a ſingle channel, they divide into different branches, and the intervals are filled up by the materials they have themſelves brought thither. Moraſſes daily dry up; lands forſaken by the ſea are cultivated, we navigate countries now covered by waters; in ſhort, we ſee ſo many inſtances of land changing into water, and water into land, that we muſt be convinced of theſe alterations having, and will continue to take place; ſo that in time gulphs will become continents; iſthmuſſes, ſtraits; moraſſes, dry lands; and the tops of our mountains the ſhoals of the ſea.

Since then the waters have covered, and may ſucceſſively cover, every part of the preſent dry land, our ſurpriſe muſt ceaſe at finding every where marine productions and compoſitions which could only be the works of the waters. We have already explained how the horizontal ſtrata of the earth were formed, but the perpendicular diviſions that are commonly found in rocks, clays, and all matters of which the globe is compoſed, ſtill remain to be conſidered. Theſe perpendicular ſtratas are, in fact, placed much farther from each other than the horizontal, and the ſofter the matter the greater the diſtance; in marble and hard earths they are frequently found only a few feet; but if the maſs of rock be very extenſive, then theſe fiſſures are at ſome fathoms diſtant; ſometimes they deſcend from the top of the rock to the bottom, and ſometimes terminate at an horizontal fiſſure. They are always perpendicular in the ſtrata of calcinable matters, as chalk, marle, marble, &c. but are more oblique and irregularly placed in vitrifiable ſubſtances, brown freeſtone, and rocks of flint, where they are frequently adorned with chryſtals, and other minerals. In quarries of marble or calcinable ſtone, the diviſions are filled with ſpar, gypſum, gravel, and an earthy ſand, which contains a great quantity of chalk. In clay, marles, and every other kind of earth, excepting turf, theſe perpendicular diviſions are either empty or filled with ſuch matters as the water has tranſported thither.

We need ſeek very little farther for the cauſe and origin of thoſe perpendicular cracks. The materials by which the different ſtrata are compoſed being carried by the water, and depoſited as a kind of ſediment, muſt neceſſarily, at firſt, contain a conſiderable ſhare of water, the which, as they began to harden, they would part with by degrees, and, as they muſt neceſſarily leſſen in the courſe of drying, that decreaſe would occaſion them to ſplit at irregular diſtances. They naturally ſplit in a perpendicular direction, becauſe in that direction, the action of gravity of one particle upon another has no actual effect, while, on the contrary, it is directly oppoſite in an horizontal ſituation; the diminution of bulk therefore could have no ſenſible effect but in a vertical line. I ſay it is the diminution by drying, and not the contained water forcing a place to iſſue, is the cauſe of theſe perpendicular fiſſures, for I have often obſerved that the two ſides of thoſe fiſſures anſwer throughout their whole height, as exactly as two ſides of a ſplit piece of wood; their inſides are rough and irregular, whereas if they had been made by the motion of the water, they would have been ſmooth and poliſhed; therefore theſe cracks muſt be produced ſuddenly and at once, or by degrees in drying, like the flaws in wood, and the greateſt part of the water they contained evaporated through the pores. The diviſions of theſe perpendicular cracks vary greatly as to the extent of their openings; ſome of them being not more than half an inch, others encreaſing to one or two feet; there are ſome many fathoms, and which form thoſe precipices ſo often met with in the Alps and other high mountains. The ſmall ones are produced by drying alone, but thoſe which extend to ſeveral feet are the effects of other cauſes; for inſtance, the ſinking of the foundation on one ſide while the other remains unmoved; if the baſe ſinks but a line or two, it is ſufficient to produce openings of many feet in a rock of conſiderable height. Sometimes rocks, which are founded on clay or ſand, incline to one ſide, by which motion the perpendicular cracks become extended.

I have not yet mentioned thoſe large openings which are found in rocks and mountains; they muſt have been produced by great ſinkings, as of immenſe caverns, unable longer to ſupport the weight with which they were encumbered, but theſe intervals are very different from perpendicular fiſſures; they appear to be vacancies opened by the hand of Nature for the communication of nations. In this manner all vacancies in large mountains and diviſions, by ſtraits in the ſea, ſeem to preſent themſelves; ſuch as the ſtraits of Thermopyles, the ports of Caucaſus, the Cordeliers, the extremity of the ſtraits of Gibraltar, the entrance of the Helleſpont, &c. theſe could not have been occaſioned by the ſimple ſeparation by drying of matter, but by conſiderable parts of the lands themſelves being ſunk, ſwallowed up, or overturned.

Theſe great ſinkings, though produced by accidental cauſes, hold a firſt place in the principal circumſtances in the Hiſtory of the Earth, and not a little contributed to change the face of the Globe; the greateſt part of them have been produced by ſubterraneous fires, whoſe exploſions cauſe earthquakes and volcanos; the force of theſe inflamed and confined matters in the bowels of the earth is beyond compare; by it cities have been ſwallowed up, provinces overturned, and mountains overthrown. But however great this force may be, and prodigious as the effects appear, we cannot aſſent to the opinion of thoſe authors who ſuppoſe theſe ſubterraneous fires proceed from an immenſe abyſs of flame in the centre of the earth, neither give we credit to the common notion that they proceed from a great depth below the ſurface of the earth, air being abſolutely neceſſary for the ſupport of inflammation. In examining the materials which iſſue from volcanos, even in the moſt violent eruptions, it appears very plain, that the furnace of the inflamed matters is not at any great depth, as they are ſimilar to thoſe found in mountains, disfigured only by the calcination, and the melting of the metallic parts which they contain; and to be convinced that the matters caſt out by volcanos do not come from any great depth, we have only to conſider of the height of the mountain, and judge of the immenſe force that would be neceſſary to caſt up ſtones and minerals to the height of half a league; for Ætna, Hecla, and many other volcanos have at leaſt that elevation from the plains. Now it is perfectly well known that the action of fire is equal in every direction; it cannot therefore act upwards, with a force capable of throwing large ſtones half a league high, without an equal re-action downwards, and on the ſides, and which re-action muſt very ſoon pierce and deſtroy the mountain on every ſide, becauſe the materials which compoſe it are not more denſe and firm than thoſe thrown out; how then can it be imagined that the cavity, which muſt be conſidered as the type or cannon, could reſiſt ſo great a force as would be neceſſary to raiſe thoſe bodies to the mouth of the volcano? Beſides, if this cavity was deeper, as the external orifice is not great, it would be impoſſible for ſo large a quantity of inflamed and liquid matter to iſſue out at once, without claſhing againſt each other, and againſt the ſides of the tube, and by paſſing through ſo long a ſpace they would run the chance of being extinguiſhed and hardened. We often ſee rivers of bitumen and melted ſulphur, thrown out of the volcanos with ſtones and minerals, flow from the tops of the mountains into the plains; is it natural to imagine that matters ſo fluid, and ſo little able to reſiſt violent action, ſhould be elevated from any great depth? All the obſervations that can be made on this ſubject will prove that the fire of the volcano is not far from the ſummit of the mountain, and that it never deſcends to the level of the plain.

This idea of volcanos does not, however, render it inconſiſtent that they are the cauſe of earthquakes, and that their ſhocks may be felt on the plains to very conſiderable diſtances; nor that one volcano may not communicate with another by means of ſubterraneous paſſages; but it is of the depth of the fire's confinement that we now ſpeak, and which can only be at a ſmall diſtance from the mouth of the volcano. It is not neceſſary to produce an earthquake on a plain, that the bottom of the volcano ſhould be below the level of that plain; nor that there ſhould be internal cavities filled with the ſame combuſtible matter, for a violent exploſion, ſuch as generally attends an eruption may, like that of a powder magazine, give ſo great a ſhock by its re-action, as to produce an earthquake that might be felt at a conſiderable diſtance.

I do not mean to ſay that there are no earthquakes produced by ſubterraneous fires, but merely that there are ſome which proceed only from the exploſion of volcanos. In confirmation of what has been advanced on this ſubject, it is certain that volcanos are ſeldom met with on plains; on the contrary, they are conſtantly found in the higheſt mountains, and their mouths at the very ſummit of them. If the internal fires of the volcanos extended below the plains, would not paſſages be opened in them during violent eruptions? In the firſt eruption would not theſe fires rather have pierced the plains, where, by compariſon, the reſiſtance muſt be infinitely weaker, than force their way through a mountain more than half a league in height.

The reaſon why volcanos appear alone in mountains, is, becauſe much greater quantities of minerals, ſulphur, and pyrites, are contained in mountains, and more expoſed than in the plains; beſides which, thoſe high places are more ſubject to the impreſſions of air, and receive greater quantities of rains and damps, by which mineral ſubſtances are capable of being heated and fermented into an abſolute ſtate of inflammation.

In ſhort, it has often been obſerved, that, after violent eruptions, the mountains have ſhrunk and diminiſhed in proportion to the quantity of matter which has been thrown out; another proof that the volcanos are not ſituated at the bottom of the mountain, but rather at no great diſtance from the ſummit itſelf.

In many places earthquakes have formed conſiderable hollows, and even ſeparations in mountains; all other inequalities have been produced at the ſame time with the mountains themſelves by the currents of the ſea, for in every place where there has not been a violent convulſion, the ſtrata of the mountains are parallel, and their angles exactly correſpond. Thoſe ſubterraneous caverns which have been produced by volcanos are eaſily to be diſtinguiſhed from thoſe formed by water; for the water, having waſhed away the ſand and clay with which they were filled, leaves only the ſtones and rocks, and this is the origin of caverns upon hills; while thoſe found upon the plains are commonly nothing but ancient pits and quarries, ſuch as the ſalt quarries of Maeſtricht, the mines of Poland, &c. But natural caverns belong to mountains: they receive the water from the ſummit and its environs, from whence it iſſues over the ſurface wherever it can obtain a paſſage; and theſe are the ſources of ſprings and rivers, and whenever a cavern is filled by any part falling in, an inundation generally enſues.

From what we have related, it is eaſy to be ſeen how much ſubterraneous fires contribute to change the ſurface and internal part of the globe. This cauſe is ſufficiently powerful to produce very great effects: but it is difficult to conceive how the winds ſhould occaſion any ſenſible alterations upon the earth. The ſea appears to be their empire, and, indeed, excepting the tides, nothing has ſo powerful an influence upon the ocean; even the flux and reflux move in an uniform manner, and their effects are regularly the ſame; but the action of the winds is capricious and violent; they ſometimes ruſh on with ſuch impetuoſity, and agitate the ſea with ſuch violence, that from a calm, ſmooth, and tranquil plain, it becomes furrowed with waves rolling mountains high, and daſhing themſelves to pieces againſt the rocks and ſhores. The winds cauſe conſtant alterations on the ſurface of the ſea, but the ſurface of the land, which has ſo ſolid an appearance, we ſhould ſuppoſe would not be ſubject to ſimilar effects; by experience, however, it is known that the winds raiſe mountains of ſand in Arabia and Africa; and that they cover plains with it; they frequently tranſport ſand to great diſtances, and many miles into the ſea, where they accumulate in ſuch quantities as to form banks, downs, and even iſlands. It is alſo known that hurricanes are the ſcourge of the Antilles, Madagaſcar, and other countries, where they act with ſuch fury, as to ſweep away trees, plants, and animals, together with the ſoil which gave them ſubſiſtence. they cauſe rivers to aſcend and deſcend, and produce new ones; they overthrow rocks and mountains; they make holes and gulphs in the earth, and entirely change the face of thoſe unfortunate countries where they exiſt. Happily there are but few climates expoſed to the impetuoſity of thoſe dreadful agitations of the air.

But the greateſt and moſt general changes in the ſurface of the earth are produced by rains, floods, and torrents from the high lands. Their origins proceed from the vapours which the ſun raiſes above the ſurface of the ocean, and which the wind tranſports through every climate. Theſe vapours, which are ſuſtained in the air, and conveyed at the will of the winds, are ſtopped in their progreſs by the tops of the hills which they encounter, where they accumulate until they become clouds and fall in the form of rain, dew, or ſnow. These waters at firſt deſcend upon the plains without any fixed courſe, but by degrees hollow out a bed for themſelves; by their natural bent they run to the bottom of mountains, and penetrating or diſſolving the land eaſieſt to divide, they carry earth and ſand away with them, cut deep channels in the plains, form themſelves into rivers, and open a paſſage into the ſea, which conſtantly receives as much water from the land rivers as it loſes by evaporation. The windings in the channels of rivers have ſinuoſities, whoſe angles are correſpondent to each other, ſo that where the waves form a ſaliant angle on one ſide, the other has an exactly oppoſite one; and as hills and mountains, which may be conſidered as the banks of the vallies which ſeparate them, have alſo ſinuoſities in correſponding angles, it ſeems to demonſtrate that the vallies have been formed, by degrees, by the currents of the ſea, in the ſame manner as the rivers have hollowed out their beds in the earth.

The waters which run on the ſurface of the earth, and ſupport its verdure and fertility, are not perhaps one half of thoſe which the vapours produce; for there are many veins of water which ſink to great depths in the internal part of the earth. In ſome places we are certain to meet with water by digging; in others, not any can be found. In almoſt all vallies and low grounds water is certain to be met with at moderate depths; but, on the contrary, in all high places it cannot be extracted from the bowels of the earth, but muſt be collected from the heavens. There are countries of great extent where a ſpring cannot be found, and where all the water which ſupplies the inhabitants and animals with drink is contained in pools and ciſterns. In the eaſt, eſpecially in Arabia, Egypt, and Perſia, wells are extremely ſcarce, and the people have been obliged to make reſervoirs of a conſiderable extent to collect the waters as it falls from the Heavens. Theſe works, projected and executed from public neceſſity, are the moſt beautiful and magnificent monuments of the eaſtern nations; ſome of the reſervoirs occupy a ſpace of two ſquare miles, and ſerve to fertilize whole provinces, by means of baths and ſmall rivulets that let it out on every ſide. But in low countries, where the greateſt rivers flow, we cannot dig far from the ſurface, without meeting with water, and in fields ſituate in the environs of rivers it is often obtained by a few ſtrokes with a pick-axe.

The water, found in ſuch quantities in low grounds, comes principally from the neighbouring hills and eminences ; at the time of great rains or ſudden melting of ſnow, a part of the water flows on the ſurface, but moſt of it penetrates through the ſmall cracks and crevices it finds in the earth and rocks. This water ſprings up again to the ſurface wherever it can find vent ; but it often filters through the ſand until it comes to a bottom of clay or ſolid earth, where it forms ſubterraneous lakes, rivulets, and perhaps rivers, whoſe courſes are entirely unknown ; they muſt, however, follow the general laws of nature, and conſtantly flow from the higher grounds to the lower, and conſequently theſe ſubterraneous waters muſt, in the end, fall into the ſea, or collect in ſome low place, either on the ſurface or in the interior part of the earth ; for there are ſeveral lakes into which no rivers enter, nor from which there are not any iſſue ; and a much greater number, which do not receive any conſiderable river, that are the ſources of the greateſt rivers on earth ; ſuch as the lake of St. Laurence ; the lake Chiamè, from whence ſpring two great rivers that water the kingdoms of Aſam and Pegu ; the lake of Aſſiniboil in America ; thoſe of Ozera in Muſcovy, that give riſe to the river Irtis, and a great number of others. Theſe lakes, it is evident, muſt be produced by the waters from the high lands paſſing through ſubterraneous paſſages, and collecting in the loweſt places. Some indeed have aſſerted that lakes are to be found on the ſummit of the higheſt mountains ; but to this no credit can be given, for thoſe found on the Alps, and other elevated places, are all ſurrounded by much more lofty mountains, and derive their origin from the waters which run down the ſides, or are filtered through thoſe eminences in the ſame manner as the lakes in the plains obtain their ſources from the neighbouring hills which over-top them.

It is apparent, therefore, that lakes have exiſtence in the bowels of the earth, eſpecially under large plains and extenſive vallies. Mountains, hills, and all eminences have either a perpendicular or inclined ſituation, and are expoſed on all ſides ; the waters which fall on their ſummits, after having penetrated into the earth, cannot fail, from the declivity of the ground, of finding iſſue in many places, and breaking in forms out of ſprings and fountains, and conſequently there will be little, if any water, remain in the mountains. On the contrary, in plains, as the water which filters through the earth can find no vent, it muſt collect in ſubterraneous caverns, or be diſperſed and divided among ſand and gravel. It is theſe waters which are ſo univerſally diffuſed through low grounds. The bottom of a pit or well is nothing elſe but a kind of baſon into which the waters that iſſue from the adjoining lands inſinuate themſelves, at firſt falling drop by drop, but afterwards, as the paſſages are opened, it receives ſupplies from greater diſtances, and then continually runs in little ſtreams or rills; from which circumſtance, although we can find water in any part of a plain, yet we can obtain a ſupply but for a certain number of wells, proportionate to the quantity of water diſperſed, or rather to the extent of the higher lands from whence they come.

It is unneceſſary to dig below the level of the river to find water; it is generally met with at much leſs depths, and there is no appearance that waters of rivers filter far through the earth. The origin of waters found in the earth below the level of rivers are not to be attributed to them; for in rivers or torrents which are dried up, or whoſe courſes have been turned, we find no greater quantity of water by digging in their beds than in the neighbouring lands at an equal depth.

A piece of land of five or ſix feet in thickneſs is ſufficient to contain water, and prevent it from eſcaping; and I have often obſerved that the banks of brooks and pools are not ſenſibly wet at ſix inches diſtance from the water.

It is true that the extent of the filtration is in proportion as the ſoil is more or leſs penetrable; but if we examine the ſtanding pools with ſandy bottoms, we ſhall perceive the water confined in the ſmall compaſs it had hollowed itſelf, and the moiſture ſpread but a very few inches; even in vegetable earth it has no great extent, which muſt be more porous than ſand or hard ſoil. It is a certain fact, that in a garden we may almoſt inundate one bed without thoſe nearly adjoining feeling any moiſture from it *. I have examined pieces of garden ground, eight or ten feet thick, which had not been ſtirred for many years, and whoſe ſurface was nearly level, and found that the rain water never penetrated deeper than three or four feet; and on turning it up in the ſpring, after a wet winter, I found it as dry as when firſt heaped together.

I made the ſame obſervation on earth which had laid in ridges two hundred years; below three or four feet it was as dry as duſt; from which it is plain that water does not extend ſo far by filtration as has been generally imagined.

By this means, therefore, the internal part of the earth can be ſupplied with a very ſmall part; but water by its own weight deſcends from the ſurface to the greateſt depths; it ſinks through natural conduits, or penetrates ſmall paſſages for itſelf; it follows the roots of trees, the cracks in rocks, the interſtices in the earth, and divides and extends on all ſides into an infinity of ſmall branches and rills, always de-

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* Theſe facts are ſo eaſily demonſtrated, that the ſmalleſt obſervation will prove their veracity.

ſcending until its paſſage is oppoſed by clay or ſome ſolid body, where it continues collecting, and at length breaks out in form of ſprings upon the ſurface.

It would be very difficult to make an exact calculation of the quantity of ſubterraneous waters which have no apparent vent. Many have pretended that it greatly ſurpaſſes all the waters that are on the ſurface of the earth.

Without mentioning thoſe who have advanced that the interior part of the globe is entirely filled with water, there are ſome who believe there are an infinity of floods, rivulets, and lakes in the bowels of the earth. But this opinion does not ſeem to be properly founded, and it is more probable that the quantity of ſubterraneous water, which never appears on the ſurface, is not very conſiderable; for if theſe ſubterraneous rivers are ſo very numerous, why do we never ſee any of their mouths forcing their way through the ſurface? Beſides, rivers, and all running waters, produce great alterations on the ſurface of the earth; they tranſport the ſoil, wear away the moſt ſolid rocks, and diſplace all matters which oppoſe their paſſage. It would certainly be the ſame in ſubterraneous rivers; the ſame effects would be produced; but no ſuch alterations have ever as yet been obſerved; the different ſtrata remains parallel, and every where preſerves its original poſition; and it is but in a very few places that any conſiderable ſubterraneous veins of water have been diſcovered. Thus water in the internal part of the earth, though great, acts but in a ſmall degree, as it is divided in an infinity of little ſtreams, and retained by a number of obſtacles; and being ſo generally diſperſed, it gives riſe to many ſubſtances totally different from primitive matters, both in form and organization.

From all theſe obſervations we may fairly conclude, that it is the continual motion of the flux and reflux of the ſea which has produced mountains, vallies, and other inequalities on the ſurface of the earth; that it is the currents of the ocean which have hollowed vallies, raiſed hills, and given them correſponding directions; that it is thoſe waters of the ſea which, by tranſporting earth, &c. and depoſiting them in horizontal layers, have formed the parallel ſtrata; that it is the waters from heaven, which by degrees deſtroy the effects of the ſea, by continually lowering the ſummit of mountains, filling up vallies, and ſtopping the mouths of gulphs and rivers, and which, by bringing all to a level, will, in the courſe of time, return this earth to the ſea, which, by its natural operations, will again form new continents, containing vallies and mountains exactly ſimilar to thoſe which we at preſent inhabit.

PROOF OF THE THEORY OF THE EARTH.

ARTICLE I.

ON THE FORMATION OF THE PLANETS.

OUR ſubject being Natural Hiſtory, we would willingly diſpenſe with aſtronomical obſervations; but as the nature of the earth is ſo cloſely connected with the heavenly bodies, and ſuch obſervations being calculated to illuſtrate more fully what has been ſaid, it is neceſſary to give ſome general ideas of the formation, motion, figure of the earth and other planets.

The earth is a globe of about three thouſand leagues diameter; it is ſituate one thouſand millions of leagues from the ſun, around which it makes its revolution in three hundred and ſixty-five days. This revolution is the reſult of two forces, the one may be conſidered as an impulſe from right to left, or from left to right, and the other an attraction from above downwards, or beneath upwards, to a common centre. The direction of theſe two forces, and their quantities, are ſo nicely combined and proportioned, that they produce an almoſt uniform motion in an illipſe, very near to a circle. Like the other planets the earth is opaque, it throws out a ſhadow ; it receives and reflects the light of the ſun, round which it revolves in a ſpace of time proportioned to its relative diſtance and denſity. It alſo turns round its own axis once in twenty-four hours, and its axis is inclined 66$\frac{1}{4}$ degrees on the plane of the orbit. Its figure is ſpheriodical, the two axes of which differ about 160th part from each other, and the ſmalleſt axis is that round which the revolution is made.

Theſe are the principal phenomena of the earth, the reſult of diſcoveries made by means of geometry, aſtronomy, and navigation. We ſhall not here enter into the detail of the proofs and obſervations by which thoſe facts have been aſcertained, but only make a few remarks to clear up what is ſtill doubtful, and at the ſame time give our ideas reſpecting the formation of the planets, and the different changes thro' which it is poſſible they have paſſed before they arrived at the ſtate we at preſent ſee them.

There have been ſo many ſyſtems and hypotheſes framed upon the formation of the terreſtrial globe, and the changes which it has undergone, that we may preſume to add our conjectures to thoſe who have written upon the ſubject, eſpecially as we mean to ſupport them with a greater degree of probability than has hitherto been done: and we are the more inclined to deliver our opinion upon this ſubject, from the hope that we ſhall enable the reader to pronounce on the difference between an hypotheſis drawn from poſſibilities, and a theory founded on facts; between a ſyſtem, ſuch as we are here about to preſent, on the formation and original ſtate of the earth, and a phyſical hiſtory of its real condition, which has been given in the preceding diſcourſe.

Galileo having found the laws of falling bodies, and Kepler having obſerved that the area deſcribed by the principal planets in moving round the ſun, and thoſe of the ſatellites round the planets to which they belong, are proportionable to the time of their revolutions, and that ſuch periods were alſo in proportion to the ſquare roots of the cubes of their diſtances from the ſun, or principal planets. Newton found that the force which cauſed heavy bodies to fall on the ſurface of the earth, extended to the moon, and retained it in its orbit; that this force diminiſhed in the ſame proportion as the ſquare of the diſtance increaſed, and conſequently that the moon is attracted by the earth; that the earth and planets are attracted by the ſun; and that in general all bodies which revolve round a centre, and deſcribe areas proportioned to the times of their revolution, are attracted towards that point. This power, known by the name of *gravity*, is therefore diffuſed throughout all matter; planets, comets, the ſun, the earth, and all nature, is ſubject to its laws, and it ſerves as a baſis to the general harmony which reigns in the univerſe. Nothing is better proved in phyſics than the actual exiſtence of this power in every material ſubſtance. Obſervation has confirmed the effects of this power, and geometrical calculations have determined the quantity and relations of it.

This general cauſe being known, the effects would eaſily be deduced from it, if the action of the powers which produce it were not too complicated. A ſingle moment's reflection upon the ſolar ſyſtem will fully demonſtrate the difficulties that have attended this ſubject; the principal planets are attracted by the ſun, and the ſun by the planets; the ſatellites are alſo attracted by their principal planets, and each planet attracts all the reſt, and is attracted by them. All theſe actions and reactions vary according to the quantities of matter and the diſtances, and produce great inequalities and irregularities. How is ſo great a number of connections to be combined and eſtimated? It appears almoſt impoſſible in ſuch a crowd of objects to follow any particular one; nevertheleſs thoſe difficulties have been ſurmounted, and calculation has confirmed the ſuppoſitions of them, each obſervation is become a new demonſtration, and the ſyſtematic order of the univerſe is laid open to the eyes of all thoſe who can diſtinguiſh truth from error.

We feel ſome little ſtop, by the force of impulſion remaining unknown; but this, however, does not by any means affect the general theory. We evidently ſee the force of attraction always draws the planets towards the ſun, they would fall in a perpendicular line, on that planet, if they were not repelled by ſome other power that obliges them to move in a ſtraight line, and which impulſive force would compel them to fly off the tangents of their reſpective orbits, if the force of attraction ceaſed one moment. The force of impulſion was certainly communicated to the planets by the hand of the Almighty, when he gave motion to the univerſe; but we ought as much as poſſible to abſtain in phyſics from having recourſe to ſupernatural cauſes; and it appears that a probable reaſon may be given for this impulſive force, perfectly accordant with the law of mechanics, and not by any means more aſtoniſhing than the changes and revolutions which may and muſt happen in the univerſe.

The ſphere of the ſun's attraction does not confine itſelf to the orbs of the planets, but extends to a remote diſtance, always decreaſing in the ſame ratio as the ſquare of the diſtance increaſes; it is demonſtrated that the comets which are loſt to our ſight, in the regions of the ſky, obey this power, and by it their motions, like that of the planets, are regulated. All theſe ſtars, whoſe tracts are ſo different, move round the ſun, and deſcribe areas proportioned to the time ; the planets in ellipſes more or leſs approaching a circle, and the comets in narrow ellipſes of a great extent. Comets and planets move, therefore, by virtue of the force of attraction and impulſion, which continually acting at one time obliges them to deſcribe theſe courſes ; but it muſt be remarked that comets paſs over the ſolar ſyſtem in all directions, and that the inclinations of their orbits are very different, inſomuch that, although ſubject like the planets to the force of attraction, they have nothing in common with reſpect to their progreſſive or impulſive motions, but appear in this reſpect independent of each other : the planets, on the contrary, move round the ſun in the ſame direction, and almoſt in the ſame plane, never exceeding 7½ degrees of inclination in their planes, the moſt diſtant from their orbits. This conformity of poſition and direction in the motion of the planets, neceſſarily implies that their impulſive force has been communicated to them by one and the ſame cauſe.

May it not be imagined, with ſome degree of probability, that a comet falling into the body of the ſun, will diſplace and ſeparate ſome parts from the ſurface, and communicate to them a motion of impulſion, inſomuch that the planets may formerly have belonged to the body of the ſun, and been detached therefrom by an impulſive force, and which they ſtill preſerve.

This ſuppoſition appears to be at leaſt as well founded as the opinion of Leibnitz, who ſuppoſes that the earth and planets have formerly been ſuns ; and his ſyſtem, of which an account will be given in the fifth article, would have been more comprehenſive and more agreeable to probability, if he had raiſed himſelf to this idea. We agree with him in thinking that this effect was produced at the time when Moſes ſaid that God divided light from darkneſs ; for, according to Leibnitz, light was divided from darkneſs when the planets were extinguiſhed ; but in our ſuppoſition there was a real phyſical ſeparation, ſince the opaque bodies of the planets were divided from the luminous matter which compoſes the ſun.

This idea of the cauſe of the impulſive force of the planets will be found much leſs objectionable, when an eſtimation is made of the analogies and degrees of probability, by which it may be ſupported. In the firſt place, the motion of the planets is in the ſame direction, from Weſt to Eaſt, and therefore, according to calculation, it is ſixty-four to one that ſuch would not have been the caſe if they had not been indebted to the ſame cauſe for their impulſive forces.

This, probably, will be conſiderably augmented by the ſecond analogy, viz. that the inclination of the planes of the orbits do not exceed $7\frac{1}{2}$ degrees; for, by comparing the ſpaces, we ſhall find there is twenty-four to one, that two planets are found in their moſt diſtant places at the ſame time, and conſequently $\frac{5}{4}$, or 7,692,624 to one, that all ſix would by chance be thus placed; or what amounts to the ſame, there is a great degree of probability that the planets have been impreſſed with one common moving force, and which has given them this poſition. But what can have beſtowed this common impulſive motion, but the force and direction of the bodies by which it was originally communicated? it may therefore be concluded, with great probability, that the planets received their impulſive motion by one ſingle ſtroke. This likelihood, which is almoſt equivalent to a certainty,

tainty, being eſtabliſhed, I ſeek to know what moving bodies could produce this effect, and I find nothing but comets capable of communicating a motion to ſuch vaſt bodies.

By examining the courſe of comets, we ſhall be eaſily perſuaded, that it is almoſt neceſſary for ſome of them occaſionally to fall into the ſun. That of 1680 approached ſo near, that at its perihelium it was not more diſtant from the ſun than a ſixteenth part of its diameter, and if it returns, as there is every appearance it will, in 2255, it may then poſſibly fall into the ſun; that muſt depend on the rencounters it will meet with in its road, and of the retardment it ſuffers in paſſing through the atmoſphere of the ſun *.

We may, therefore, preſume with the great Newton, that comets ſometimes fall into the ſun; but this fall may be made in different directions. If they fall perpendicular, or in a direction not very oblique, they will remain in the ſun, and ſerve for food to the fire which that luminary conſumes, and the motion of impulſion which they will have communicated to the ſun, will produce no other effect than that of removing it more or leſs, according as the maſs of the comet will be more or leſs conſi-

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* Vide Newton, 2d edit. page 525.

conſiderable: but if the fall of the comet is in a very oblique direction, which will moſt frequently happen, then the comet will only graze the ſurface of the ſun, or ſlightly furrow it; and in this caſe it may drive out ſome parts of matter to which it will communicate a common motion of impulſion, and theſe parts ſo forced out of the body of the ſun, and even the comet itſelf may then become planets, and turn round this luminary in the ſame direction, and in almoſt the ſame plane. We might perhaps calculate what quantity of matter, velocity, and direction a comet ſhould have, to impel from the ſun an equal quantity of matter to that which the ſix planets and their ſatellites contain; but it will be ſufficient to obſerve here, that all the planets, with their ſatellites, do not make the 650th part of the maſs of the ſun *, becauſe the denſity of the large planets, Saturn and Jupiter, is leſs than that of the ſun; and although the earth be four times, and the moon near five times more denſe than the ſun, they are nevertheleſs but as atoms in compariſon with his extenſive body.

However inconſiderable the 650th part may be, yet it certainly at firſt appears to require a very powerful comet to ſeparate even that much from

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* Vid. Newton, page 405.

from the body of the ſun; but if we reflect on the prodigious velocity of comets in their perihelion, a velocity ſo much the greater as they approach nearer the ſun; if, beſides, we pay attention to the denſity and ſolidity of the matter of which they muſt be compoſed, to ſuffer, without being deſtroyed, the inconceivable heat they endure; and conſider the bright and ſolid light which ſhines through their dark and immenſe atmoſpheres, which ſurround and muſt obſcure them, it cannot be doubted that the comets are compoſed of extremely ſolid and denſe matters, and that they contain a greater quantity of matter in a ſmall compaſs; that conſequently a comet of no extraordinary bulk may have ſufficient weight and velocity to diſplace the ſun, and give a projectile motion to a quantity of matter, equal to the 650th part of the maſs of this luminary. This perfectly agrees with what is known concerning the denſity of planets, which always decreaſes as their diſtance from the ſun is increaſed, they having leſs heat to ſupport; ſo that Saturn is leſs denſe than Jupiter, and Jupiter much leſs than the earth; therefore if the denſity of the planets be, as Newton aſſerts, proportionable to the quantity of heat which they have to ſupport, Mercury will be ſeven times more denſe than the earth, and twenty-eight times denſer than the ſun; and the comet of 1680 would be 28,000 times denſer than the earth, or 112,000 times denſer than the ſun, and by ſuppoſing it as large as the earth, it would contain nearly an equal quantity of matter to the ninth part of the ſun, or by giving it only the 100th part of the ſize of the earth, its maſs would ſtill be equal to the 900th part of the ſun. From whence it is eaſy to conclude, that ſuch a body, though it would be but a ſmall comet, might ſeparate and drive off from the ſun a 900th or a 650th part, particularly if we attend to the immenſe velocity with which comets move when they paſs in the vicinity of the ſun.

Beſides this, the conformity between the denſity of the matter of the planets, that of the ſun deſerves ſome attention. It is well known that both on and near the ſurface of the earth, there are ſome matters 14 or 1500 times denſer than others. The denſities of gold and air are nearly in this relation. But the internal parts of the earth and planets are compoſed of a more uniform matter, whoſe comparative denſity varies much leſs; and the conformity in the denſity of the planets and that of the ſun is ſuch, that of 650 parts which compoſe the whole of the matter of the planets, there are more than 640 of the ſame denſity as the matter of the ſun, and only ten parts out of theſe 650 which are of a greater denſity, for Saturn and Jupiter are nearly of the ſame denſity as the ſun, and the quantity of matter which theſe planets contain, is at leaſt 64 times greater than that of the four inferior planets, Mars, the Earth, Venus and Mercury. We muſt therefore admit that the matter of which the planets are generally compoſed is nearly the ſame as that of the ſun, and that conſequently the one may have been ſeparated from the other.

But it may be ſaid, if the comet, by falling obliquely on the ſun, drove off the matter which compoſe the planets, they, inſtead of deſcribing circles of which the ſun is the centre, would, on the contrary, at each revolution, have returned to the ſame point from whence they departed, as every projectile would which might be thrown off with ſufficient force from the ſurface of the earth, to oblige it to turn perpetually: for it is eaſy to demonſtrate that ſuch, in that inſtance, would be the caſe, and therefore that the projection of the planets from the ſun cannot be attributed to the impulſion of a comet.

To this I reply, that the matter which compoſes the planets did not come from the ſun, in ready formed globes, but in the form of torrents, the motion of the anterior parts of which were accelerated by that of the poſterior; and that the attraction of the anterior parts alſo accelerated the motion of the poſterior, and that this acceleration produced by one or other of theſe cauſes, or perhaps by both, might be ſo great as to change the original direction of the motion occaſioned by the impulſe of the comet, from which cauſe a motion has reſulted, ſuch as we at preſent obſerve in the planets; eſpecially when it is conſidered the ſun is diſplaced from its ſtation by the ſhock of the comet. An example will render this more reaſonable; let us ſuppoſe, that from the top of a mountain a muſket ball is diſcharged, and that the ſtrength of the powder was ſufficient to ſend it beyond the ſemi-diameter of the earth, it is certain that this ball would paſs round the earth, and at each revolution return to the ſpot from whence it had been diſcharged:

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but, if inſtead of a muſket-ball, we ſuppoſe a rocket had been diſcharged, wherein the action of the fire being durable, would greatly accelerate the motion of impulſion ; this rocket, or rather the cartouch which contained it, would not return to the ſame place like the muſket-ball, but would deſcribe an orbit, whoſe perigee would be much farther diſtant from the earth, as the force of acceleration would be greater, and have changed the firſt direction.

Thus, provided there had been any acceleration in the motion of impulſion communicated to the torrent of matter by the fall of the comet, it is probable that the planets formed in this torrent, acquired the motion which we know they have in the circles and ellipſis of which the ſun is the center and focus.

The manner in which the great eruptions of volcanos are made, may afford us an idea of this acceleration of motion. It has been remarked that when Veſuvius begins to roar and eject the inflamed matter it contains, the firſt cloud has but a ſmall degree of velocity, but which is ſoon accelerated by the impulſe of the ſecond ; the ſecond by the action of a third, and ſo on, until the heavy maſs of bitumen,

men, ſulphur, cinders, melted metal, and huge ſtones, appear like maſſive clouds, and although they ſucceed each other nearly in the ſame directions, yet they greatly change that of the firſt, and drive it far beyond what it would have reached of itſelf.

In anſwer to this objection, it may be further obſerved, that the ſun having been ſtruck by the comet, received a degree of motion by the impulſe, which diſplaced it from its former ſituation; and that although this motion of the ſun is at preſent too little ſenſible for the notice of aſtronomers, nevertheleſs it may ſtill exiſt, and the ſun deſcribe a curve round the centre of gravity of the whole ſyſtem; and if this is ſo, as I preſume it is, we ſee perfectly that the planets, inſtead of returning near the ſun at each revolution, will, on the contrary, have deſcribed orbits, the points of the perihelion of which will be as far diſtant from the ſun, as it is itſelf from the place it originally occupied.

It may alſo be ſaid, that if this acceleration of motion is made in the ſame direction, no change in the perihelion will be produced: but can it be thought that in a torrent, the particles of which ſucceed each other, there has been no change of direction; it is, on the contrary, very probable that a conſiderable change did take place, ſufficient to cauſe the planets to move in the courſe they at preſent occupy.

It may be further urged, that if the ſun had been diſplaced by the ſhock of a comet, it would move uniformly, and that hence this motion being common to the whole ſyſtem, no alteration was neceſſary; but might not the ſun before the ſhock have had a motion round the centre of the cometry ſyſtem, to which primitive motion the ſtroke of the comet may have added or diminiſhed? and would not that fully account for the actual motion of the planets?

If theſe ſuppoſitions are not admitted, may it not be preſumed, that in the ſtroke of the comet againſt the ſun, there was an elaſtic force which raiſed the torrent above the ſurface of the ſun, inſtead of directly impelling it? which alone would be ſufficient to remove the perihelion, and give the planets the motion they have retained. This ſuppoſition is not without probability, for the matter of the ſun may poſſibly be very elaſtic, ſince light, the only part of it we are acquainted with, ſeems, by its effects, to be perfectly ſo. I own that I cannot ſay whether it is by the one or the other of theſe reaſons, that the direction of the firſt motion of the impulſe of the planets has changed, but they ſuffice to ſhew that ſuch an alteration is not only poſſible but even probable, and that is ſufficient for my purpoſe.

But, without dwelling any longer on the objections which might be made, I ſhall purſue the ſubject, and draw the fair concluſions on the proofs which analogies might furniſh in favour of my hypotheſis: let us, therefore, firſt ſee what might happen when theſe planets, and particularly the earth, received their impulſive motion, and in what ſtate they were after having been ſeparated from the ſun. The comet having, by a ſingle ſtroke, communicated a projectile motion to a quantity of matter equal to the 650th part of the ſun's maſs, the light particles would of courſe ſeparate from the denſe, and form, by their mutual attraction, globes of different denſities: Saturn being compoſed of the moſt groſs and light parts would be the moſt remote from the ſun: Jupiter being more denſe than Saturn, would be leſs diſtant, and ſo on. The larger and leaſt ſolid planets are the moſt remote, becauſe they received an impulſive motion ſtronger than the ſmalleſt and more denſe: for, the force of impulſion communicating itſelf according to the ſurface, the ſame ſtroke will have moved the groſſer and lighter parts of the matter of the ſun with more velocity than the ſmalleſt and more weighty; a ſeparation therefore will be made of the denſe parts of different degrees, ſo that the denſity of the ſun being equal to 100, that of Saturn will be equal to 67, that of Jupiter to 94½, that of Mars to 200, that of the Earth to 400, that of Venus to 800, and that of Mercury to 2800. But the force of attraction not communicating like that of impulſion, according to the ſurface, but acting on the contrary on all parts of the maſs, it will have checked the denſeſt portions of matter; and it is for this reaſon that the denſeſt planets are the nigheſt the ſun, and turn round that planet with greater rapidity than the leſs denſe planets, which are alſo the moſt remote.

Jupiter and Saturn, which are the largeſt and principal planets of the ſolar ſyſtem, have retained the relation between their denſity and impulſive motions, in the moſt exact proportions; the denſity of Saturn is to that of Jupiter as 67 to 94½, and their velocities are nearly as $88\frac{2}{3}$ to $120\frac{1}{72}$, or as 67 to $90\frac{11}{16}$; it is ſeldom that pure conjectures can draw ſuch exact relations. It is true, that by following this relation between the velocity and denſity of planets, the denſity of the earth ought to be only as $206\frac{7}{18}$, and not 400, which is its real denſity ; from hence it may be conceived, that our globe was formerly leſs denſe than it is at preſent. With reſpect to the other planets, Mars, Venus, and Mercury, as their denſities are known only by conjecture, we cannot be certain whether this circumſtance will deſtroy or confirm our hypotheſis. The opinion of Newton is, that denſity is ſo much the greater, as the heat to which the planet is expoſed is the ſtronger ; and it is on this idea that we have juſt ſaid that Mars is one time leſs denſe than the Earth, Venus one time, Mercury ſeven times, and the comet in 1680, 28,000 times denſer than the earth : but this proportion between the denſity of the planets, and the heat which they ſuſtain, ſeems not well founded, when we conſider Saturn and Jupiter, which are the principal objects ; for according to this relation between the denſity and heat, the denſity of Saturn would be about $4\frac{7}{18}$ and that of Jupiter as $14\frac{17}{22}$, inſtead of 67 and

$94\frac{1}{2}$, a difference too great to be admitted, and muſt deſtroy the principles upon which it was founded. Thus, notwithſtanding the confidence which the conjectures of Newton merit, I can but think that the denſity of the planets has more relation with their velocity than with the degree of heat to which they are expoſed. This is only a final cauſe, and the other a phyſical relation, the preciſeneſs of which is remarkable in Jupiter and Saturn: it is nevertheleſs true, that the denſity of the earth, inſtead of being $206\frac{7}{8}$, is found to be 400, and that conſequently the terreſtrial globe muſt be condenſed in this ratio of $206\frac{7}{8}$ to 400.

But have not the condenſations of the planets ſome relation with the quantity of the heat of the ſun which they ſuſtain? if ſo, Saturn, which is the moſt diſtant from that luminary, will have ſuffered little or no condenſation; and Jupiter will be condenſed from $90\frac{11}{16}$ to $94\frac{1}{2}$. Now the heat of the ſun in Jupiter being to that of the ſun upon the earth as $14\frac{17}{22}$ are to 400, the condenſations ought to be in the ſame proportion. For inſtance, if Jupiter be condenſed, as $90\frac{11}{16}$ to $94\frac{1}{2}$, and the earth had been placed in his orbit; it would have been condenſed from $206\frac{7}{8}$ to $215\frac{990}{1451}$, but the earth being nearer the ſun, and receiving a heat, whoſe relation to that which Jupiter receives is from 400 to $14\frac{17}{22}$, the quantity of condenſation it would have experienced in the orbit of Jupiter by the proportion of 400 to $14\frac{17}{22}$, which gives nearly $234\frac{1}{3}$ for the quantity which the earth would be condenſed. Its denſity was $206\frac{7}{8}$, by adding the quantity of its acquired condenſation, we find $400\frac{7}{8}$ for its actual denſity, which nearly approaches the real denſity 400, determined to be ſo by the parallax of the moon. As to other planets, I do not here pretend to give exact proportions, but only approximations, to point out that their denſities have a ſtrong relation to their velocity in their reſpective orbits.

The comet, therefore, by its oblique fall upon the ſurface of the ſun, having driven therefrom a quantity of matter equal to the 650th part of its whole maſs; this matter, which muſt be conſidered in a liquid ſtate, will at firſt have formed a torrent, the groſſer and leſs denſe parts of which will have been driven the fartheſt, and the ſmaller and more denſe having received only the like impulſion, will remain neareſt its ſource; the force of the ſun's attraction would inevitably act upon all the parts detached from him, and conſtrain them to circulate around his body, and at the ſame time the mutual attraction of the particles of matter would form themſelves into globes at different diſtances from the ſun, the neareſt of which neceſſarily moving with greater rapidity in their orbits than thoſe at a diſtance.

But another objection may be ſtarted, and it may be ſaid, if the matter which compoſes the planets had been ſeparated from the ſun, they, like him, would have been burning and luminous bodies, not cold and opaque, for nothing reſembles a globe of fire leſs than a globe of earth and water; and by compariſon, the matter of the earth and planets is perfectly different from that of the ſun?

To this it may be anſwered, that in the ſeparation the matter changed its form, and the light or fire was extinguiſhed by the ſtroke which cauſed this motion of impulſion. Beſides, may it not be ſuppoſed that if the ſun, or a burning ſtar moved with ſuch velocity as the planet, that the fire would ſoon be extinguiſhed; and that is the reaſon why all luminous ſtars are fixed, and that thoſe ſtars which are called new, and which have probably changed places, are frequently extinguiſhed and loſt? This remark is ſomewhat confirmed by what has been obſerved on comets, they muſt burn to the centre when they paſs to their perihelium: nevertheleſs they do not become luminous themſelves, they only exhale burning vapours, of which they leave a conſiderable part behind them in their courſe.

I own, that in a medium where there is very little or no reſiſtance, fire may ſubſiſt and ſuffer a very great motion without being extinguiſhed: I alſo own, that what I have juſt ſaid extends only to the ſtars which totally diſappear, and not to thoſe which have periodical returns, and appear and diſappear alternately without changing place in the heavens. The phenomena of theſe ſtars has been explained in a very ſatisfactory manner by M. de Maupertuis, in his diſcourſe on the figures of the planets. But the ſtars which appear and afterwards diſappear entirely, muſt certainly have been extinguiſhed, either by the velocity of their motion, or ſome other cauſe. We have not a ſingle example of one luminous ſtar revolving round another; and among the number of planets which compoſe our ſyſtem, and which move round the ſun with more or leſs rapidity, there is not one luminous of itſelf.

It may alſo be added, that fire cannot ſubſiſt ſo long in the ſmall as in large maſſes, and that the planets muſt have burnt for ſome time after they were ſeparated from the ſun, but were at length extinguiſhed for want of combuſtible matter, as probably will be the ſun itſelf, and for the ſame reaſon; but in a length of time as far beyond that which extinguiſhed the planets, as it exceeds in quantity of matter. Be this as it may, the matter of which the planets are formed being ſeparated from the ſun, by the ſtroke of a comet, that appears a ſufficient reaſon for the extinction of their fires.

The earth and planets at the time of their quitting the ſun, were in a ſtate of total liquid fire; in this ſtate they remained only as long as the violence of the heat which had produced it; and which heat neceſſarily underwent a gradual decay: it was in this ſtate of fluidity that they took their circular forms, and that their regular motions raiſed the parts of their equators, and lowered their poles. This figure, which agrees ſo perfectly with the laws of hydroſtatics, I am of opinion with Leibnitz, neceſſarily ſuppoſes that the earth and planets have been in a ſtate of fluidity, cauſed by fire, and that the internal part of the earth muſt be a vitrifiable matter, of which ſand, granite, &c. are the fragments and ſcoria.

It may, therefore, with ſome probability, be thought that the planets appertained to the ſun, that they were ſeparated by a ſingle ſtroke which gave to them a motion of impulſion, and that their poſition at different diſtances from the ſun proceeds only from their different denſities. It now only remains, to complete this theory, to explain the diurnal motion of the planets, and the formation of the ſatellites; but this, far from adding difficulties to my hypotheſis, ſeems, on the contrary, to confirm it.

For the diurnal motion, or rotation, depends ſolely on the obliquity of the ſtroke, an oblique impulſe therefore on the ſurface of a body will neceſſarily give it a rotative motion; this motion will be equal and always the ſame, if the body which receives it is homogeneous, and it will be unequal if the body is compoſed of heterogeneous parts, or of different denſities; hence we may conclude that in all the planets the matter is homogeneous, ſince their diurnal motions are equal, and regularly performed in the ſame period of time. Another proof that the ſeparation of the denſe and leſs denſe parts were originally from the ſun.

But the obliquity of the ſtroke might be ſuch, as to ſeparate from the body of the principal planet a ſmall part of matter, which would of courſe continue to move in the ſame direction; theſe parts would be united, according to their denſities, at different diſtances from the planet, by the force of their mutual attraction, and at the ſame time follow its courſe around the ſun, by revolving about the body of the planet, nearly in the plane of its orbit. It is plain, that thoſe ſmall parts ſo ſeparated are the ſatellites: thus the formation, poſition, and direction of the motions of the ſatellites perfectly agree with our theory; for they have all the ſame motion in concentrical circles round their principal planet; their motion is in the ſame direction, and that nearly in the plane of their orbits. All theſe effects, which are common to them, and which depend on an impulſive force, can proceed only from one common cauſe, which is, impulſive motion, communicated to them by one and the ſame oblique ſtroke.

What we have juſt ſaid on the cauſe of the motion and formation of the ſatellites, will acquire more probability, if we conſider all the circumſtances of the phenomena. The planets which turn the ſwifteſt on their axis, are thoſe which have ſatellites. The earth turns quicker than Mars in the relation of about 24 to 15; the earth has a ſatellite, but Mars has none. Jupiter, whoſe rapidity round its axis is five to ſix hundred times greater than that of the earth, has four ſatellites, and there is a great appearance that Saturn, which has five, and a ring, turns ſtill more quickly than Jupiter.

It may even be conjectured with ſome foundation, that the ring of Saturn is parallel to the equator of the planet, ſo that the plane of the equator of the ring, and that of Saturn, are nearly the ſame; for by ſuppoſing, according to the preceding theory, that the obliquity of the ſtroke by which Saturn has been ſet in motion was very great, the velocity around the axis, will, at firſt, have been in proportion as the centrifugal force exceeds that of gravity, and there will be detached from its equator and neighbouring parts, a conſiderable quantity of matter, which will neceſſarily have taken the figure of a ring, whoſe plane muſt be nearly the ſame as that of the equator of the planet; and this quantity of matter having been detached from the vicinity of the equator of Saturn, muſt have lowered the equator of that planet, which cauſes that, notwithſtanding its rapidity, the diameters of Saturn cannot be ſo unequal as thoſe of Jupiter, which differ from each other more than an eleventh part.

However great the probability of what I have advanced on the formation of the planets and their ſatellites may appear to me, yet, every man has his particular meaſurement, to eſtimate probabilities of this nature, and as this meaſurement depends on the ſtrength of the underſtanding to combine more or leſs diſtant relations, I do not pretend to convince the incredulous. I have not only thought it my duty to offer theſe ideas, becauſe they appear to me reaſonable, and calculated to clear up a ſubject, on which, however important, nothing has hitherto been written. but becauſe the impulſive motion of the planets enters at leaſt as one half in the compoſition of the univerſe, which gravity alone cannot unfold. I ſhall only add the following queſtions to thoſe who are inclined to deny the poſſibility of my ſyſtem.

1. Is it not natural to imagine, that a body in motion has received that motion by the ſtroke of another body?

2. Is it not very probable, that when many bodies move in the ſame direction, that they have received this direction by one ſingle ſtroke, or by many ſtrokes directed in the ſame manner?

3. Is it not more probable, that when many bodies have the ſame direction in their motion, and are placed in the ſame plane, that they received this direction and this poſition by one and the ſame ſtroke, rather than by a number?

4. At the time a body is put in motion by the force of impulſion, is it not probable that it receives it obliquely, and, conſequently, is obliged to turn on its axis ſo much the quicker, as the obliquity of the ſtroke will have been greater? If theſe queſtions ſhould not appear unreaſonable, the theory, of which we have preſented the outlines, will ceaſe to appear an abſurdity.

Let us now paſs on to ſomething which more nearly concerns us, and examine the figure of the earth, on which ſo many reſearches and ſuch great obſervations have been made. The earth being, as it appears by the equality of its diurnal motion and the conſtancy of the inclination of its axis, compoſed of homogeneous parts, which attract each other in proportion to their quantity of matter, it would neceſſarily have taken the figure of a globe perfectly ſpherical, if the motion of impulſation had been given it in a perpendicular direction to the ſurface; but this ſtroke having been obliquely given, the earth turned on its axis at the moment it took its form; and from the combination of this impulſive force, the attraction of the parts, there has reſulted a ſpheroid figure, more elevated under the great circle of rotation, and lower at the two extremities of the axis, and this becauſe the action of the centrifugal force proceeding from the diurnal rotation muſt diminiſh the action of gravity. Thus, the earth being homogeneous, and having received a rotative motion, neceſſarily took a ſpheroidical figure, the two axes of which differ a 230th part from each other. This may be clearly demonſtrated, and does not depend on any hypotheſis whatever. The laws of gravity are perfectly known, and we cannot doubt that bodies attract each other in a direct ratio of their maſſes, and in an inverted ratio, at the ſquares of their diſtances: ſo likewiſe we cannot doubt, that the general action of any body is not compoſed of all the particular actions of its parts. Thus each part of matter mutually attracts in a direct ratio of its maſs and an inverted ratio of its diſtance, and from all theſe attractions there reſults a ſphere when there is no rotatory motion, and a ſpheroid when there is one. This ſpheroid is longer or ſhorter at the two extremities of the axis of rotation, in proportion to the velocity of its diurnal motion, and the earth has then, by virtue of its rotative velocity, and of the mutual attraction of all its parts, the figure of a ſpheroid, the two axis of which are as 229 to 230 to one another.

Thus, by its original conſtitution, by its homogeneouſneſs, and independent of every hypotheſis from the direction of gravity, the earth has taken this figure of a ſpheroid at its formation, and agreeable to mechanical laws: its equatorial diameter was raiſed about 6½ leagues higher than under the poles.

I ſhall dwell on this article, becauſe there are ſtill geometricians who think that the figure of the earth depends upon theory, and this from a ſyſtem of philoſophy they have embraced, and from a ſuppoſed direction of gravity. The firſt thing we have to demonſtrate is, the mutual attraction of every part of matter, and the ſecond the homogeneouſneſs of the terreſtrial globe: if we clearly prove, that theſe two circumſtances are really ſo, there will no longer be any hypotheſis to be made on the direction of gravity: the earth will neceſſarily have the figure Newton decided in favour of, and every other figure given to it by virtue of vortexes or other hypotheſes, will not be able to ſubſiſt.

It cannot be doubted, that it is the force of gravity which retains the planets in their orbits; the ſatellites of Saturn gravitate towards Saturn, thoſe of Jupiter towards Jupiter, the Moon gravitates towards the Earth: and Saturn, Jupiter, Mars, the Earth, Venus and Mercury, gravitate towards the ſun: ſo likewiſe Saturn and Jupiter gravitate towards their ſatellites, the earth gravitates towards the moon, and the ſun towards the whole of the planets. Gravitation is therefore general and mutual in all the planetary ſyſtem, for action cannot be exerciſed without a re-action; all the planets, therefore, act mutually one on the other. This mutual attraction ſerves as a foundation to the laws of their motion, and is demonſtrated to exiſt by its effects. When Saturn and Jupiter are in conjunction, they act one on the other, and this attraction produces an irregularity in their motion round the ſun. It is the ſame with the Earth and the Moon, they alſo mutually attract each other; but the irregularities of the motion of the Moon, proceeds from the attraction of the Sun, ſo that the Earth, the Sun, and the Moon, mutually act one on the other. Now this mutual attraction of the planets, when the diſtances are equal, is proportional to their quantity of matter, and the ſame force of gravity which cauſes heavy matter to fall on the ſurface of the Earth, and which extends to the Moon, is alſo proportional to the quantity of matter; therefore the total gravity of a planet is compoſed of the gravity of each of its parts; from whence all the parts of matter, either in the Earth or in the planets, mutually attract each other; and the Earth, by its rotation round its own axis, has neceſſarily taken the figure of a ſpheroid, the axes of which are as 229 to 230. The direction of the weight muſt be perpendicular to the Earth's ſurface; conſequently no hypotheſis, drawn from the direction of gravity, can be ſuſtained, unleſs the general attraction of the parts of matter be denied; but the exiſtence of this mutual attraction is demonſtrated by obſervations, and the experiment of pendulums prove, that its extenſion is general; therefore we cannot ſupport an hypotheſis on the direction of gravity without going againſt experience and reaſon.

Let us now proceed to examine whether the matter of which the terreſtrial globe is compoſed be homogeneous. I admit, that if it is ſuppoſed the globe is more denſe in ſome parts than in others, the direction of gravity muſt be different from what we have juſt aſſigned, and that the figure of the Earth would alſo differ agreeable to thoſe ſuppoſitions. But what reaſon have we to make theſe ſuppoſitions? why, for example, ſhould we ſuppoſe that the parts near the centre are denſer than thoſe which are more remote? Are not all the particles which compoſe the globe collected together by their mutual attraction?

hence, each particle is a centre, and there is no reaſon to believe, that the parts which ſurround the centre, are denſer than thoſe which are about any other point. Beſides, if one conſiderable part of the globe was denſer than another, the axis of rotation would be found near the denſe parts, and an inequality would enſue in the diurnal revolution; we ſhould remark an inequality in the apparent motion of the fixed ſtars; they would appear to move more quick or ſlow in the zenith, or horizon, according as we ſhould be placed on the denſer or lighter parts of the earth; and the axis of the globe no longer paſſing through the centre of gravity, would alſo very ſenſibly change its poſition: but nothing like this ever happens; on the contrary, the diurnal motion of the earth is equal and uniform. At all parts of the Earth's ſurface, the ſtars appear to move with the ſame velocity at all heights, and if there be any rotation in its axis, it is ſo trifling as to have eſcaped obſervation: it muſt therefore be concluded, that the globe is homogeneous, or nearly ſo in all its parts.

If the earth was a hollow and void globe, and the cruſt of which, for example, not more than two or three miles thick; it would produce theſe effects. 1. The mountains would be ſuch conſiderable parts of the whole thickneſs of the cruſt, that great irregularities in the motions of the Earth would be occaſioned by the attraction of the Moon and Sun: for when the higheſt parts of the globe, as the Cordeliers, ſhould have the Moon at noon, the attraction would be much ſtronger on the whole globe than when ſhe was in the meridian of the loweſt parts. 2. The attraction of mountains would be much more conſiderable than it is in compariſon with the attraction of the whole globe, and experiments made at the mountain of Chimboraco, in Peru, would in this caſe give more degrees than they have given ſeconds for the deviation of the plumb line. 3. The weight of bodies would be greater on the tops of high mountains, than on the plains; ſo that we ſhould feel ourſelves conſiderably heavier, and ſhould walk with more difficulty in high than in low places. Theſe obſervations, with many others that might be added, muſt convince us, that the inner parts of the globe is not void, but filled with a denſe matter.

On the other hand, if below the depth of two or three miles, the earth was filled with a matter a matter much more denſe than any known, it would neceſſarily occur, that every time we deſcended to moderate depths, we ſhould weigh much more, and the motion of pendulums would be more accelerated than in fact they are when carried from an eminence into a plain: thus, we may preſume that the internal part of the Earth is filled with a matter nearly ſimilar to that which compoſes its ſurface. What may complete our determination in favour of this opinion is, that in the firſt formation of the globe, when it took its preſent ſpheroidical figure, the matter which compoſed it was in fuſion, and, conſequently, all its parts were homogeneous and nearly equally denſe. From that time the matter on the ſurface, although originally the ſame with the interior, has undergone a variety of changes by external cauſes, which has produced materials of ſuch different denſities; but it muſt be remarked, that the denſeſt matters, as gold and metals, are alſo thoſe the moſt ſeldom to be met with, and conſequently the greateſt part of the matter at the ſurface of the globe, has not undergone any very great changes with relation to its denſity; the moſt common materials, as ſand and clay, differ very little, inſomuch, that we may conjecture, with great probability, that the internal part of the earth is compoſed of a vitrified matter, the denſity of which is nearly the ſame as that of ſand, and that conſequently the terreſtrial globe in general may be regarded as homogeneous.

Notwithſtanding this, it may be urged, that although the globe was compoſed of concentrical ſtrata of different denſities, the diurnal motion might be equally certain, and the uniform inclination of the axis as conſtant and undiſturbed as it could be, on the ſuppoſition of its being compoſed of homogeneous matter. I acknowledge it, but I aſk at the ſame time, if there is any reaſon to believe that ſtrata of different denſities do exiſt? If theſe concluſions be not rather a deſire to adjuſt the works of Nature to our own ideas? And whether in phyſics we ought to admit ſuppoſitions which are not founded on obſervations or analogy.

It appears, therefore, that the earth, by virtue of the mutual attraction of its parts and its diurnal motion aſſumed the figure of a ſpheroid, that it neceſſarily took that form from being in a ſtate of fluidity, that, agreeable to the laws of gravity and of a centrifugal force, it could have no other figure: that in the moment of its formation as at preſent, there was a difference between the two diameters equal to a 230th part, and that, conſequently, every hypotheſis in which we find greater or leſs difference are fictions which merit no attention.

But it may be ſaid, if this theory is true, and if 229 to 230 is the juſt relation of the axis, why did the mathematicians ſent to Lapland and Peru, agree to the relation of 174 to 175? From whence does this difference ariſe between theory and practice? And is it not more reaſonable to give the preference to practice and meaſures, eſpecially when they have been taken by the moſt able mathematicians of Europe*, and with all neceſſary apparatus to eſtabliſh the reſult.

To this I anſwer, that I have paid attention to the obſervations made at the equator and near the polar circle; that I have no doubt of their being exact, and that the earth may poſſibly be elevated an 175th part more at the equator than at the poles. But, at the ſame time, I maintain my theory, and I ſee clearly how the two concluſions may be reconciled. This difference is about four leagues in the two axes, ſo that the parts at the equator are raiſed two leagues more than they ought to be, according to my theory; this height anſwers exactly to the greateſt inequalities on the ſurface of the globe, produced by the motion of the ſea, and the action of the fluids. I will explain; it appears that when the earth was formed, it muſt neceſſarily have taken, by virtue of the mutual attraction of its parts, and the action of the centrifugal force, a ſpheroidical figure, the axes of which differ a 230th part: the original earth muſt have had this figure, which it took when it was fluid, or rather liquified by the fire; but after its formation, the vapours which were extended and rarefied, as in the atmoſphere and tail of a comet, became condenſed, and fell on the ſurface in form of air and water: and when theſe waters became agitated by the flux and reflux, the matters were, by degrees, carried from the poles towards the equatorial parts; ſo that the poles were lowered about a league, and thoſe of the equator raiſed in the ſame proportion; this was not ſuddenly done, but by degrees in ſucceſſion of time; the earth being alſo expoſed to the action of the winds, air, and ſun; all theſe irregular cauſes concurred with the flux and reflux to furrow its ſurface, hollow it into valleys, and raiſe it into mountains; and producing other inequalities and irregularities, of which, neverthelеſs, the greateſt thickneſs does not exceed one league at the equator; this inequality of two leagues, is, perhaps, the greateſt which can be on the ſurface of the earth, for the higheſt mountains are ſcarce above one league in height, and there is much probability of the ſea's not being more at its greateſt depth. The theory is therefore true, and practice may be ſo likewiſe; the earth at firſt could not be raiſed above 6½ leagues more at the equator than the poles, but the changes which have happened to its ſurface, might afterwards raiſe it ſtill more. Natural Hiſtory wonderfully confirms this opinion, for we have proved in the preceding diſcourſe that the flux and reflux, and other motions of the water, have produced mountains and all the inequalities on the ſurface of the globe, that this ſurface has undergone conſiderable changes, and that at the greateſt depths, as well as on the greateſt heights, bones, ſhells, and other wrecks of animals, which inhabit the ſea and earth, are met with.

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* M. de Maupertuis' Figure of the Earth.

It may be conjectured, from what has been ſaid, that to find ancient earth, and matters which have never been removed from the ſpot in which they were firſt placed, we muſt dig near the poles, where the bed of the earth muſt be thinner than in the Southern climates.

On the whole, if we ſtrictly examine the meaſures by which the figure of the earth is determined, we ſhall perceive this hypotheſis enters into ſuch determination; for it ſuppoſes the earth to have the figure of a regular curve, whereas from the conſtant changes the earth is continually undergoing, from a variety and combination of cauſes, it is almoſt impoſſible that it ſhould have retained any regular figure, and hence the poles might, originally, only be flattened a 230th part, as Newton ſays, and as my theory requires. Beſides, although we had exactly the length of the degree at the polar circle and equator, have we not alſo the length of the degree as exactly in France? And the meaſure of M. Picard, has it not been verified? Add to this, that the augmentation and diminution in the motion of the pendulum, do not agree with the reſult drawn from meaſurement, and that, on the contrary, they differ very little from the theory of Newton. This is ſurely more than is requiſite to convince us that the poles are not flattened more than a 230th part, and that if there is any difference, it can proceed only from the inequalities which the water and other external cauſes have produced on its ſurface; but theſe inequalities being more irregular than regular, we muſt not form any hypotheſis thereon, nor ſuppoſe, that the meridians are ellipſiſes, or any other regular curves. From whence we perceive, that if we ſhould ſucceſſively meaſure many degrees of the earth in all directions, we ſtill ſhould not be certain by that alone, of the exact ſituation of the poles, nor whether they were depreſſed more or leſs than the 230th part.

May it not alſo be conjectured, that if the inclination of the axis of the earth has changed, it can only be produced by the changes which have happened to the ſurface, ſince all the reſt of the globe is homogeneous; that conſequently this variation is too little ſenſible to be perceived by aſtronomers, and that if the earth is not encountered with a comet, or deranged by any other external cauſe, its axis will remain perpetually inclined as it is at preſent, and as it has always been.

In order not to omit any conjecture which appears reaſonable, may it not be ſaid, that as the mountains and inequalities which are on the ſurface of the earth have been formed by the flux and reflux of the ſea, the mountains and inequalities which we remark on the ſurface of the moon, have been produced by a ſimilar cauſe; they certainly are much higher than thoſe of the earth, but then her tides are alſo much ſtronger, occaſioned by the earth's being conſiderably larger than the moon, and conſequently producing her tides with a ſuperior force; and this effect would be much greater if the moon had, like the earth, a rapid rotation; but as the moon preſents always the ſame ſurface to the earth, the tides cannot operate but in proportion to the motion ariſing from her libration, by which it alternatively diſcovers to us a ſegment of its other hemiſphere; this, however, muſt produce a kind of flux and reflux, quite different from that of our ſea, and the effects of which will be much leſs conſiderable than if the moon had from its courſe a revolution round its axis, as quick as the rotation of the terreſtrial globe.

I ſhould furniſh a volume as large as that of Burnet or Whiſton's, if I were to enlarge on the ideas which ariſe in ſupport of the above; by giving them a geometrical air in imitation of the laſt author, I might add conſiderably to their weight; but, in my opinion, hypotheſes, however probable, ought not to be treated with ſuch pompoſity, it being a dreſs which borders ſo much on quackery.

ARTICLE II.

FROM THE SYSTEM OF WHISTON *.

THIS Author commences his treatiſe by a diſſertation on the creation of the world; he ſays, that the account of it given by Moſes in the text of Geneſis has not been rightly underſtood; that the tranſlators have confined themſelves too much to the letter and ſuperficial views, without attending to nature, reaſon, and philoſophy. The common notion of the world being made in ſix days, he ſays is abſolutely falſe, and that the deſcription given by Moſes, is not an exact and philoſophical narration of the creation and origin of the univerſe, but only an hiſtorical repreſen-

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* A New Theory of the Earth by William Whiſton, 1708.

tation of the terreſtrial globe. The Earth, according to him, exiſted in the chaos; and, at the time mentioned by Moſes, received the form, ſituation, and conſiſtency neceſſary to be inhabited by the human race. I ſhall not enter into a detail of his proofs, nor undertake their refutation. The expoſition we have juſt made, is ſufficient to demonſtrate the difference of his opinion with public facts, its contrariety with ſcripture, and conſequently the inſufficiency of his proofs. On the whole, he treats this matter as a theological controvertiſt, rather than as an enlightened philoſopher.

Leaving theſe erroneous principles, he flies to ingenious ſuppoſitions, and, although extraordinary, yet have a degree of probability to thoſe who, like him, incline to the enthuſiaſm of ſyſtem. He ſays, that the ancient chaos, the origin of our Earth, was the atmoſphere of a comet: that the annual motion of the Earth began at the time it took its new form, but that its diurnal motion began only when the firſt man fell. That the eliptic cut the tropic of cancer, oppoſite to the terreſtrial paradiſe, which was ſituated on the north-weſt ſide of the frontiers of Aſſyria: that before the Deluge, the year began at the autumnal equinox:

that the orbits of the Planets, and the Earth were then perfect circles. That the Deluge began the 18th of November, 2365, of the Julian period, or 2349 years before Chriſt. That the ſolar and lunar year were then the ſame, and that they exactly contained 360 days. That a comet deſcending in the plane of the eliptic towards its perihelion, paſſed near the globe of the Earth the ſame day as the Deluge began: that there is a great heat in the internal part of the terreſtrial globe, which conſtantly diffuſes itſelf from the centre to the circumference; that the form of the Earth is like that of an egg, the ancient emblem of the globe; that mountains are the lighteſt part of the Earth, &c. He afterwards attributes all the alterations and changes which have happened to the Earth, to the univerſal Deluge; then blindly adopts the theory of Woodward, and indiſcriminately makes uſe of all the obſervations of that author, on the preſent ſtate of the globe; but aſſumes originality when he ſpeaks of its future ſtate: according to him it will be conſumed by fire, and its deſtruction will be preceded by terrible earthquakes, thunder, and frightful meteors; the ſun and moon will have an hideous aſpect, the heavens will appear to fall, and the flames will be general over all the Earth: but when the fire ſhall have devoured all the impurities it contains; when it ſhall be vitrified and rendered tranſparent as cryſtal, the ſaints, and the bleſſed ſpirits will return and take poſſeſſion of it, and there remain till the day of judgment.

Theſe hypotheſes, at the firſt glance appear to be raſh, and extravagant aſſertions: nevertheleſs the author has managed them with ſuch addreſs, and treated them with ſuch ſtrength, that they ceaſe to appear abſolutely chimerical. He ſupports his ſubjects with much ſcience, and it is ſurpriſing, that from a mixture of ideas ſo very abſurd, a ſyſtem could be formed with an air of probability. It has not affected vulgar minds ſo much as it has dazzled the eyes of the learned, becauſe they are more eaſily deceived by the glare of erudition, and the power of novel idea. Mr. Whiſton was a celebrated aſtronomer, in the conſtant habit of conſidering the heavens, obſerving the ſtars, and contemplating the wonderful courſe of nature; he could never perſuade himſelf that this ſmall grain of ſand, this Earth which we inhabit, occupied more the attention of the Creator than the univerſe, the vaſt extent of which contains millions of other Suns and Earths. He pretends, that Moſes has not given us the hiſtory of the firſt creation of this globe; but only a detail of the new form that it took when the Almighty turned it from the maſs of a comet into a planet, and formed it into a proper habitation for men. Comets are, in fact, ſubjected to terrible viciſſitudes by reaſon of the eccentricity of their orbits. Sometimes, like that in 1680, it is a thouſand times hotter there than red hot iron; and ſometimes a thouſand times colder than ice; if they are, therefore, inhabited, it muſt be by ſtrange creatures, of which we can have no conception.

The planets, on the contrary, are places of reſt where the diſtance from the ſun, not varying much, the temperature remains nearly the ſame, and permits different kinds of plants and animals to grow and multiply.

In the beginning God created the world; but, obſerves our author, the earth was then an uninhabitable comet, ſuffering alternatively the exceſs of heat and cold, its liquifying, and freezing by turns, formed a chaos, or an abyſs, ſurrounded with thick darkneſs: "And darkneſs covered the face of the deep;" *& tenebra erant ſuperfaciem abyſſi.* This chaos was the atmoſphere of the comet, a body compoſed of heterogeneous matters, the centre occupied by ſpherical, ſolid, and hot ſubſtances, of about two thouſand leagues in diameter, round which a very great ſurface of a thick fluid extended, mixed with an unſhapen and confuſed matter, like the chaos of the ancient *rudis et indigeſtaque moles.*

This vaſt atmoſphere contained but very few dry, ſolid, or terreſtrial particles, ſtill leſs aqueous or aerial, but a great quantity of fluid, denſe and heavy matters, mixed, agitated and jumbled together in the greateſt diſorder and confuſion. Such was the earth before the ſix days, but on the firſt day of the creation, when the eccentrical orbit of the comet had been changed, every thing took its place, and bodies arranged themſelves according to the law of gravity, the heavy fluid deſcended to the loweſt places, and left the upper regions to the terreſtrial, aqueous and aerial parts; thoſe likewiſe deſcended according to their order of gravity; firſt, the earth, then the water, and laſt of all the air. The immenſe volume of chaos was thus reduced to a globe of a moderate ſize, in the centre of which is the ſolid body, that ſtill retains the heat which the ſun formerly communicated to it, when it belonged to a comet.

met. This heat may poſſibly endure ſix thouſand years, ſince the comet of 1680 required fifty thouſand years to cool. Around this ſolid and burning matter, which occupies the centre of the earth, the denſe and heavy fluid which deſcended the firſt is to be found, and this is the fluid which forms the great abyſs on which the earth is borne, like cork on quickſilver; but as the terreſtrial parts were originally mixed with a large quantity of water, in deſcending they have dragged with them a part of this water, which, not being able to reaſcend after the earth was conſolidated, formed a concentrical bed with the heavy fluid which ſurrounds this hot ſubſtance, inſomuch that the great abyſs is compoſed of two concentrical orbs, the moſt internal of which is a heavy fluid, and the other water; the laſt of which ſerves for a foundation to the earth. It is from this admirable arrangement, produced by the atmoſphere of a comet, that the Theory of the Earth, and the explanation of all its phenomena are to depend.

When the atmoſphere of the comet was once diſembarraſſed from all the ſolid and terreſtrial matters, there remained only the lighter air, through which the rays of the ſun freely paſſed and inſtantly produced light: "Let there be light, and there was light." The columns which compoſed the orb of the Earth being formed with ſuch great precipitation is the cauſe of their different denſities; conſequently the heavieſt ſunk deeper into this ſubterraneous fluid than the lighteſt; and it is this which has produced the vallies and mountains on the ſurface of the earth. Theſe inequalities were, before the deluge, diſperſed and ſituated otherwiſe than they are at preſent. Inſtead of the vaſt valley, which contains the ocean, there were many ſmall divided cavities on the ſurface of the globe, each of which contained a part of this water: the mountains were alſo more divided, and did not form chains as at preſent: neverthele∫s the earth contained a thouſand times more people, and was a thouſand times more fertile; and the life of man and other animals were ten times longer, all which was effected by the internal heat of the earth that proceeded from the centre, and gave birth to a great number of plants and animals, beſtowing on them a degree of vigour neceſſary for them to ſubſiſt a long time, and multiply in great abundance. But this heat, by increaſing the ſtrength of bodies, unfortunately extended to the heads of men and animals; it augmented their paſſions; it deprived man of his innocence, and the brute creation of part of their intelligence; all creatures, excepting fiſh, who inhabited a colder element, felt the effects of this heat, became criminal and merited death. It therefore came, and this univerſal death happened on Wedneſday the 28th of November, by a terrible deluge of forty day and forty nights, and was cauſed by the tail of another comet which encountered the earth in returning from its perihelion.

The tail of a comet is the lighteſt part of its atmoſphere; it is a tranſparent miſt, a ſubtile vapour, which the heat of the ſun exhales from the body of the comet: this vapour compoſed of extremely rarefied aqueous and aerial particles, follows the comet when it deſcends to its perihelion, and precedes when it re-aſcends, ſo that it is always ſituate oppoſite to the ſun, as if it ſought to be in the ſhade, and avoid the too great heat of that luminary. The column which this vapour forms is often of an immenſe length, and the more a comet approaches the ſun, the longer and more extended is its tail, and as many comets deſcend below the annual orb of the earth, it is not ſurpriſing that the earth is ſometimes found ſurrounded with the vapour of this tail; this is preciſely what happened at the time of the deluge. In two hours the tail of a comet will evacuate a quantity of water equal to what is contained in the whole ocean. In ſhort, this tail was what Moſes calls the cataracts of Heaven, "and the cataracts of Heaven were opened." The terreſtrial globe meeting with the tail of a comet, muſt, in going its courſe through this vapour, appropriate to itſelf a part of the matter which it contains; all which, coming within the ſphere of the earth's attraction, muſt fall on it, and fall in the form of rain, ſince this tail is partly compoſed of aqueous vapours. Thus rain may come down in ſuch abundance as to produce an univerſal deluge, the waters of which might eaſily ſurmount the tops of the higheſt mountains. Nevertheleſs, our author, cautious of not going directly againſt the letter of holy writ, does not ſay that this rain was the ſole cauſe of the univerſal deluge, but takes the water from every place he can find it. The great abyſs as we ſee contains a conſiderable quantity. The earth, at the approach of the comet, would prove the force of its attraction; and the waters contained in the great abyſs would be agitated by ſo violent a kind of flux and reflux, that the ſuperficial cruſt would not reſiſt, but ſplit in ſeveral places and the internal waters be diſperſed over the ſurface, "And the fountains of the abyſs were opened."

But what became of theſe waters, which the tail of the comet and great abyſs furniſhed ſo liberally? our author is not the leaſt embarraſſed thereon. As ſoon as the earth, continuing its courſe, removed from the comet the effects of its attraction, the flux and reflux in the great abyſs ceaſed of courſe, and immediately the upper waters precipitated back with violence by the ſame roads as they had been forced upon the ſurface. The great abyſs abſorbed all the ſuperfluous waters, and was of a ſufficient capacity not only to receive its own waters, but alſo all thoſe which the tail of the comet had left, becauſe during its agitation, and the rupture of its cruſt, it had enlarged the ſpace by driving out on all ſides the earth that ſurrounded it. It was at this time alſo the figure of the earth, which till then was ſpherical, became elliptic. This effect was occaſioned by the centrifugal force cauſed by its diurnal motion, and by the attraction of the comet, for the earth, in paſſing through the tail of the comet, found itſelf ſo placed that it preſented the parts of the equator to that planet; and the power of the attraction of the comet, concurring with the centrifugal force of the earth, cauſed the parts of the equator to be elevated, and that with the more facility as the cruſt was broken and divided in an infinity of places, and becauſe the flux and reflux of the abyſs drove againſt the equator more violently than elſewhere.

Here then is Mr. Whiſton's hiſtory of the creation; the cauſes of the univerſal deluge; the length of the life of the firſt men; and the figure of the Earth; all which ſeem to have coſt our author little or no labour; but Noah's ark appears to have greatly diſquieted him. In the midſt of ſo terrible a diſorder, occaſioned by the conjunction of the tail of a comet with the waters of the great abyſs, in the terrible moments wherein not only the elements of the earth were confuſed, but when new elements ſtill concurred to augment the chaos, how can it be imagined that the ark floated quietly with its numerous cargo on the top of the waves? Here our auther makes great efforts to arrive at and give a phyſical reaſon for the preſervation of the ark, but which has always appeared to me inſufficient, poorly imagined, and but little orthodoxical: I will not here relate it, but only obſerve, how hard it is for a man who has explained objects ſo great and wonderful, without having recourſe to a ſupernatural power, to be ſtopt by one particular circumſtance; our author, however, choſe rather to riſk drowning with the ark, than to attribute to the immediate bounty of the Almighty the preſervation of this precious veſſel.

I ſhall only make one remark on this ſyſtem, of which I have made a faithful abridgement; which is, whenever we are raſh enough to attempt to explain theological truths by phyſical reaſons, or interpret purely by human views the divine text of holy writ, or that we endeavour to reaſon on the will of the Moſt High, and on the execution of his degrees, we conſequently ſhall involve ourſelves in the darkneſs and chaos of obſcurity and confuſion, like the author of this ſyſtem, which, in defiance of its abſurdities, has been received with great applauſe. He neither doubts the truth of the deluge, nor the authenticity of the ſacred writ; but as he was leſs employed with it than with phyſic and aſtronomy,

nomy, he has taken paſſages of the ſcripture for phyſical facts, and the reſults of aſtronomical obſervations ; and has ſo ſtrangely blended the divine knowledge with human ſcience, as to give birth to the moſt extraordinary ſyſtem that poſſibly ever was or will be conceived.

ARTICLE III.

FROM THE SYSTEM OF BURNET *.

THIS author is the firſt who has treated this ſubject generally and in a ſyſtematical manner. He was poſſeſſed of much underſtanding, and was a perſon well acquainted with the *belles lettres*. His work acquired great reputation, and was criticiſed by many of the learned, among the reſt by Mr. Keil, who has geometrically demonſtrated the errors of Mr. Burnet, in a treatiſe called "Examination of the Theory of the Earth." Mr. Keil alſo refuted Whiſton's ſyſtem; but he treats the laſt author very different from the firſt, and ſeems even to be of his opinion in ſeveral caſes, and looks upon the tail of a comet to be a very probable cauſe for the deluge. But, to return to Burnet, his book is elegantly written; he knew how to paint noble images and magnificent ſcenes. His plan is great, but the execution is deficient for want of proper materials: his reaſoning is good, but his proofs are weak; yet his confidence in his writings is ſo great, that he frequently cauſes his readers to paſs over his errors.

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* Thomas Burnet. Telluris theoria ſacra, orbis noſtri originem & mutationes generales, quas aut jam ſubut, aut olim Subiturus eſt complectens. Londina, 1681.

He begins by telling us, that before the deluge the earth had a very different form from that which it has at preſent; it was at firſt, he ſays, a fluid maſs, compounded of matters of all kinds, and all ſorts of figures, the heavieſt deſcended towards the centre, and formed a hard and ſolid body; round which the waters collected, and the air, and all the liquors lighter than water, ſurmounted them. Between the orb of air and that of water, was an orb of oily matter, but as the air was ſtill very impure, and contained a great quantity of ſmall particles of terreſtrial matter, they by degrees deſcended on the coat of oil, and formed a terreſtrial orb blended with earth and oil; and this was the firſt habitable earth, and the firſt abode of man. This was an excellent ſoil, light, and calculated to yield to the tenderneſs of the firſt germs. The ſurface of the terreſtrial globe was at firſt equal, uniform, without mountains, without ſeas, and without inequalities; but it remained only about ſixteen centuries in this ſtate, for the heat of the ſun by degrees drying the cruſt, ſplit it at firſt on the ſurface, ſoon after theſe cracks penetrated farther and increaſed ſo conſiderably by time, that at length they entirely opened the cruſt; in an inſtant the whole earth fell into pieces in the abyſs of water it ſurrounded; and this was the cauſe of the deluge.

But all theſe maſſes of earth, by falling into the abyſs, dragged along with them a great quantity of air; theſe ſtruck againſt each other, divided, and accumulated ſo irregularly, that great cavities filled with air were left between them. The waters by degrees opened theſe cavities, and in proportion as they filled them, the ſurface of the earth diſcovered itſelf in the higheſt parts; at length water alone remained in the loweſt parts; that is to ſay, the vaſt vallies which contains the ſea. Thus our ocean is a part of the ancient abyſs, the reſt is entered into the internal cavities with which the ocean communicates. The iſlands and ſea rocks are the ſmall fragments, and continents are the great maſſes of the old cruſt. As the rupture and the fall of this cruſt are made of a ſudden, and with confuſion, it was not ſurpriſing to find eminences, depths, plains, and inequalities of all kinds on the ſurface of the earth.

ARTICLE IV.

FROM THE SYSTEM OF WOODWARD.

IT may be ſaid of this author, that he attempted to raiſe an immenſe monument on a leſs ſolid baſe than the moving ſand, and to conſtruct a world with duſt; for he pretends, that at the time of the deluge a total diſſolution of the earth was made. The firſt idea which preſents, after having gone through his book *, is, that this diſſolution was made by the waters of the great abyſs. He aſſerts, that the abyſs where the water was included opened all at once at the command of God, and diſperſed over the ſurface an enormous quantity of water neceſſary to cover the tops of the higheſt mountains, and that God ſuſpended the cauſe of coheſion which reduced all ſolid bodies into duſt, &c. He did not conſider that by theſe ſuppoſitions he added other miracles to that of the univerſal deluge, or at leaſt phyſical impoſſibilities, which agree neither with the letter of the holy writ, nor with the mathematical principles of natural philoſophy. But as this author has the merit of having collected many important obſervations, and as he was better acquainted with the materials of which the globe is compoſed than thoſe who preceded him, his ſyſtem, although badly conceived, and worſe digeſted, has neverthleſs dazzled many people, who, ſeduced by the truth of ſome particular circumſtances, put confidence in his general concluſions; we ſhall, therefore, give a ſhort view of

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* An Eſſay towards the Natural Hiſtory of the Earth, & by John Woodward.

of his theory, in which, by doing juſtice to the author's merit, and the exactneſs of his obſervations, we ſhall put the reader in a ſtate of judging of the inſufficiency of his ſyſtem, and of the falſity of ſome of his remarks. Mr. Woodward ſpeaks of having diſcovered by his ſight, that all matters which compoſe the Engliſh earth, from the ſurface to the deepeſt places which had been dug, were diſpoſed by beds of ſtrata, and that in a great number of theſe there were ſhells and other marine productions; he afterwards adds, that by his correſpondents and friends he was aſſured, that in other countries the earth is compoſed of the ſame materials, and that ſhells are found there, not only in the plains but on the higheſt mountains, in the deepeſt quarries, and in an infinity of different places. He perceived their ſtrata to be horizontal and diſpoſed one over the other as matters are which are tranſported by the waters, and depoſited in form of ſediment. Theſe general remarks, which are true, are followed by particular obſervations, by which he evidently ſhews, that foſſils found incorporated in the ſtrata are real ſhells and marine productions, not minerals and ſingular bodies, the ſport of nature, &c.

To theſe obſervations, though partly made before him, which he has collected and proved, he adds others leſs exact. He aſſerts, that all matters of different ſtrata are placed one on the other in the order of their ſpecific gravity.

This general aſſertion is not true, for we daily ſee rocks placed above clay, ſand, coal, and bitumen, and which certainly are ſpecifically heavier than either of theſe latter materials. If, in fact, we found throughout the earth that the firſt ſtrata was bitumen, then chalk, then marl, clay, ſand, ſtone, marble, and at laſt metals, ſo that the compoſition of the earth exactly followed the law of gravity, there would be an appearance that they might have been precipitated at the ſame time, which our author aſſerts with confidence, in ſpite of the evidence to the contrary; for, without being a naturaliſt, we need only have our eye-ſight to be convinced that heavy ſtrata are often found above lighter, and that conſequently theſe ſediments were not precipitated all at one time, but have been brought and depoſited ſucceſſively by the water. As this is the foundation of his ſyſtem, and is manifeſtly falſe, we ſhall follow it no farther than to ſhew how far an erroneous principle may produce falſe combinations and erroneous concluſions.

All the matters, ſays our author, which compoſe the earth, from the ſummits of the higheſt mountains, to the greateſt depths of mines, are diſpoſed by ſtrata, according to their ſpecific weights; therefore he concludes the whole has been diſſolved and precipitated at one time. But in what manner, and at what time was it diſſolved? In water, replies he, and at the time of the deluge. But there is not a ſufficient quantity of water on the globe for this to be effected, ſince there is more land than water, and the bottom of the ſea itſelf is earth. This he admits, but ſays, there is more water than is requiſite at the centre of the earth, that it was only neceſſary for it to aſcend, and poſſeſs a power of diſſolving every ſubſtance but ſhells, afterwards to find the means for this water to re-enter the abyſs, and to make all this agree with the hiſtory of the deluge. This then is the ſyſtem, of which the author does not entertain the leaſt doubt; for when it is oppoſed to him that water cannot diſſolve marble, ſtone, and metals, eſpecially in forty days, the duration of the deluge, he anſwers ſimply, that nevertheleſs it did happen ſo. When he is aſked, what the virtue of this water of the abyſs was, to diſſolve all the earth, and at the ſame time preſerve the ſhells? he ſays, that he never pretended that this water was a diſſolvent; but that it is clear, by facts, that the earth has been diſſolved and the ſhells preſerved. When he was evidently ſhewn that if he had no reaſon to give, or facts to ſupport, for theſe phenomenas, his ſyſtem was uſeleſs, he ſaid, we have only to imagine that, during the deluge, the force of gravity and the coherency of matter ceaſed on a ſudden, and by this ſuppoſition the diſſolution of the old world would be explained in a very eaſy and ſatisfactory manner. But, it was ſaid to him, if the power which holds the parts of matter united was ſuſpended, why were not the ſhells diſſolved as well as all the reſt? Here he makes a diſcourſe on the organization of ſhells and bones of animals, by which he pretends to prove that their texture being fibrous, and different from that of minerals, their power of coheſion was different alſo; after all, we have, ſays he, only to ſuppoſe that the power of gravity and coheſion did not entirely ceaſe, but that it was only diminiſhed ſufficient to diſunite all the parts of minerals, and not thoſe of animals. To all this we cannot be prevented from diſcovering, that our author's philoſophy was not equal to his talents for obſervation; and I do not think it neceſſary ſeriouſly to refute opinions which have no foundation, eſpecially when they have been imagined againſt the rules of probability, and drawn from conſequences contrary to mechanical laws.

ARTICLE V.

EXPOSITION OF SOME OTHER SYSTEMS.

IT is plain that the three forementioned hypotheſes have much in common with each other. They all agree in this point, that during the deluge the earth changed its form, as well externally as internally; but theſe ſpeculators have not conſidered that the earth before the deluge was inhabited by the ſame ſpecies of men and animals, and muſt neceſſarily have been nearly ſuch as it is at preſent. The ſacred writings teach us; that before the deluge there were rivers, ſeas, mountains, and foreſts. That theſe rivers and mountains were, for the moſt part, retained in the ſame ſituations; the Tigris and Euphrates were the rivers of the ancient paradiſe; that the mountain of Armenia, on which the ark reſted, was one of the higheſt mountains in the world at the deluge, as it is at preſent: that the ſame plants and animals which exiſt now, exiſted then; for we read of the ſerpent, of the raven, of the crow, and of the dove, which brought the olive branch into the ark. Although Tournefort aſſerts there are no olive trees for more than 400 miles from Mount Ararat, and paſſes ſome abſurd jokes thereon *, it is nevertheleſs certain there were olives in this neighbourhood at the time of the deluge, ſince holy writ aſſures us of it in the moſt expreſs terms; but it is by no means aſtoniſhing that in the ſpace of 4000 years the olive trees ſhould have been deſtroyed in thoſe quarters, and multiplied in others; it

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* Voyages du Levant, vol. 2, page 336.

it is therefore contrary to ſcripture and reaſon, that thoſe authors have ſuppoſed the earth was quite different from its preſent ſtate before the deluge ; and this contradiction between their hypotheſes and the ſacred text, as well as phyſical truths, muſt cauſe their ſyſtem to be rejected, if even they ſhould agree with ſome phenomena. Burnet gives neither obſervations, nor any real facts, for the ſupport of his ſyſtem. Woodward has only given us an eſſay, in which he promiſed much more than he could perform : his book is a project, the execution of which has not been ſeen. He has made uſe of two general obſervations ; the firſt, that the earth is every where compoſed of matters which formerly were in a ſtate of fluidity, tranſported by the waters, and depoſited in horizontal ſtrata. The ſecond, that there are abundance of marine productions in moſt parts of the bowels of the earth. To give a reaſon for theſe facts, he has recourſe to the univerſal deluge, or rather it appears that he gives them as proofs of the deluge ; but, like Burnet, he falls into evident contradictions, for it is not to be ſuppoſed with them that there were no mountains prior to the deluge, ſince it is expreſsly ſtated, that the waters roſe fifteen cubits above the tops of the higheſt mountains. On the other hand, it is not ſaid that theſe waters deſtroyed or diſſolved theſe mountains; but, on the contrary, theſe mountains remained in their places, and the ark reſted on that which the water firſt deſerted. Beſides how can it be imagined that, during the ſhort duration of the deluge, the waters were able to diſſolve the mountains and the whole body of the earth? Is it not an abſurdity to ſuppoſe that in forty days all marble, rocks, ſtones, and minerals, were diſſolved by water? Is it not a manifeſt contradiction to admit this total diſſolution, and at the ſame time maintain that ſhells, bones, and marine productions were preſerved entire, and reſiſted that which had diſſolved the moſt ſolid ſubſtances? I ſhall not therefore heſitate to ſay, that Woodward, with excellent facts and obſervations, has formed but a poor and inconſiſtent ſyſtem.

Whiſton, who came laſt, greatly enriched the other two, and notwithſtanding he gave a vaſt ſcope to his imagination has not fallen into contradiction: he ſpeaks of matters not very credible, but they are neither abſolutely nor evidently impoſſible. As we are ignorant of the centre of the earth, he thought he might ſuppoſe it was a ſolid matter, ſurrounded with a ring of heavy fluid, and afterwards with a ring of water, on which the external cruſt was ſuſtained; in the latter the different parts of this cruſt were more or leſs ſunk, in proportion to their relative weights, which produced mountains and inequalities on the ſurface of the earth. Here, however, this aſtronomer has committed a mechanical blunder; he did not recollect that the earth, according to this hypotheſis, muſt be an uniform arch, and that conſequently it could not be borne on the water it contains, and much leſs ſunk therein. I do not know that there are any other phyſical errors; but he has made a great number of errors, both in metaphyſics and theology. On the whole, it cannot be denied abſolutely that the earth meeting with the tail of a comet might not be inundated, eſpecially allowing the author that the tail of a comet, may contain aqueous vapours; nor can it be denied as an abſolute impoſſibility that the tail of a comet, in returning from its perihelium, might not burn the earth, if we ſuppoſe, with Mr. Whiſton, that the comet paſſed very near the ſun; it is the ſame with the reſt of the ſyſtem. But though his ideas are not abſolutely impoſſibilities, there is ſo little probability to each thing, when taken ſeparately, that the reſult upon the whole taken together puts it beyond credibility.

The three ſyſtems we have ſpoken of are not the only works which have been compoſed on the theory of the earth; a Memoir of M. Bourguet appeared in 1729, printed at Amſterdam, with his "Philoſophical Letters on the Formation of Salts, &c." in which he gives a ſpecimen of the ſyſtem he meditated, but which was prevented completion by the death of the author. It is but juſtice to admit, that no perſon was more induſtrious in making obſervations or collecting facts. To him we owe that great and beautiful obſervation, the correſpondence between the angles of mountains. He preſents every thing which he had collected in great order; but with all thoſe advantages, it appears that he has ſucceeded no better than the reſt in making a phyſical and reaſonable hiſtory of the changes which had happened to the globe, and that he was very wide from having found the real cauſe of thoſe effects which he relates. To be convinced of this we need only caſt our eyes on the propoſitions which he deduces from the phenomena, and which ought to ſerve for the baſis of his theory. He ſays, that the whole globe took its form at one time, and not ſucceſſively; that its form and diſpoſition proves that it has been in a ſtate of fluidity; that the preſent ſtate of the earth is very different from that in which it was for many ages after its firſt formation; that the matter of the globe was at the beginning leſs denſe than ſince it altered its appearance; that the condenſation of its ſolid parts diminiſhed by degrees with its velocity, ſo that after having made a number of revolutions on its axis, and round the ſun, it found itſelf on a ſudden in a ſtate of diſſolution, which deſtroyed its firſt ſtructure. This happened about the vernal equinox. That the ſea-ſhells introduced themſelves into the diſſolved matters; that after this diſſolution the earth took the form it now has, and that the fire which directly infuſed itſelf therein conſumed it by degrees, and it will be one day deſtroyed by a terrible exploſion, accompanied with a general conflagration, which will augment the atmoſphere of the globe, and diminiſh its diameter, and that then the earth, inſtead of beds of ſand or earth, will have only ſtrata of calcined metal and mountains, compoſed of amalgamas of different metals.

This is ſufficient to ſhew the ſyſtem M. Bourguet meditated: to divine in this manner the paſt, and predict the future, nearly as others have predicted, does not appear to me to be an effort of judgment: this author had more erudition than ſound and general views. he appears to be deficient in that capacioufneſs of ideas neceſſary to follow the extent of the ſubject, and enable him to comprehend the chain of cauſes and effects.

In the acts of Leipſic, the famous Leibnitz publiſhed a ſcheme of quite a different ſyſtem, under the title of *Protogaea*. The earth, according to Bourguet and others, muſt end by fire; according to Leibnitz it began by it, and has ſuffered many more changes and revolutions than is imagined. The greateſt part of the terreſtrial matter was ſurrounded by violent flames at the time when Moſes ſays light was divided from darkneſs. The planets, as well as the earth, were fixed ſtars, luminous of themſelves. After having burnt a long time, he pretends that they were extinguiſhed for want of combuſtible matter, and are become opaque bodies. The fire, by melting the matter,

ter, produced a vitrified cruſt, and the baſis of all the matter which compoſes the globe is glaſs, of which ſand and gravel are only fragments. The other kinds of earth are formed from a mixture of this ſand, with fixed ſalts and water, and when the cruſt cooled, the humid particles, which were raiſed in form of vapours, re-fell, and formed the ſea. They at firſt covered the whole ſurface, and even ſurmounted the higheſt mountains. According to this author, the ſhells, and other wrecks of the ſea, which are every where to be found, poſitively prove that the ſea has covered the whole earth; and the great quantity of fixed ſalts, ſand, and other melted and calcined matters, which are included in the bowels of the earth, prove that the conflagration had been general, and that it preceded the exiſtence of the ſea. Although theſe thoughts are void of proofs, they are capital. The ideas have connection, the hypotheſes are not impoſſible, and the conſequences that may be drawn therefrom are not contradictory: but the grand defect of this theory is, that it is not applicable to the preſent ſtate of the earth; it is the paſt which it explains, and this paſt is ſo far back, and has left us ſo few remains, that we may ſay what we pleaſe of it, and the probability will be in proportion as a man has talents to elucidate what he aſſerts. To affirm, as Whiſton has done, that the earth was originally a comet, or, with Leibnitz, that it has been a ſun, is ſaying things equally poſſible or impoſſible, and to which it would be ridiculous to apply the rules of probability. To ſay that the ſea formerly covered all the earth, that it ſurrounded the whole globe, and that it is for this reaſon ſhells are every where found, is not paying attention to a very eſſential point, the unity of the time of the creation; for if that was ſo, it muſt neceſſarily be admitted, that ſhell-fiſh, and other inhabitants of the ſea, of which we find the remains in the internal part of the earth, exiſted long before man, and all terreſtrial animals. Now, independent of the teſtimony of Holy Writ, is it not reaſonable to think, that all animals and vegetables are nearly as ancient as each other?

M. Scheutzer, in a diſſertation, addreſſed to the Academy of Sciences in 1728, attributes, like Woodward, the change, or rather the ſecond formation of the globe, to the univerſal Deluge; to explain that of mountains, he ſays, that after the Deluge, God chuſing to return the waters into ſubterraneous reſervoirs, broke and diſplaced with his all-powerful hand a number of beds, before horizontal, and raiſed them above the ſurface of the globe, which was originally level. The whole diſſertation is compoſed to imply this opinion. As it was requiſite theſe eminences ſhould be of a ſolid conſiſtence, M. Scheutzer remarks, that God only drew them from places where there were many ſtones; from hence, ſays he, it proceeds that thoſe countries, like Switzerland, which are very ſtony, are alſo mountainous; and on the contrary, thoſe, as Holland, Flanders, Hungary, and Poland, have only ſand or clay, even to a very great depth, and are almoſt entirely without mountains*.

This author more than any other is deſirous of blending phyſic with theology, and though he has given ſome good obſervations, the ſyſtematical part of his works is ſtill weaker than thoſe who preceded him. On this ſubject he has even made declamations and ridiculous witticiſms; as may be ſeen in his *Viſciam Quaerelæ*, &c. without ſpeaking of his large work in many folio volumes, *Phyſica Sacra*, a puerile work, which appears to be compoſed

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* See the Hiſt. of the Acad. 1708, page 32.

leſs for the inſtruction of men than for the amuſement of children.

Steno, and ſome others, have attributed the cauſe of the inequalities of the earth to particular inundations, earthquakes, &c. but the effects of theſe ſecondary cauſes have been only able to produce ſome ſlight changes. We admit of theſe cauſes after the firſt cauſe, the motion of the flux and reflux, and of the ſea from eaſt to weſt. Neither Steno, nor the reſt, have given theory, nor even any general facts on this matter *.

Ray pretends that all mountains have been produced by earthquakes, and he has compoſed a treatiſe to prove it; we ſhall ſhew under the article of volcanos what little foundation his opinion is built upon.

We cannot diſpenſe without obſerving, that Burnet, Woodward, Whiſton, and moſt of theſe other authors, have committed an error which deſerves to be cleared up; which is, to have looked upon the Deluge as poſſible by the action of natural cauſes, whereas ſcripture preſents it to us as produced by the immediate will of God; there is no natural cauſe which can produce on the whole ſurface of the earth the

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* See the Diſſ. de Solido intra Solidum, &c.

the quantity of water required to cover the higheſt mountains, and if even we could imagine a cauſe proportionate to this effect, it would ſtill be impoſſible to find another cauſe capable of cauſing the water to diſappear; allowing Whiſton, that theſe waters proceeded from the tail of a comet, we deny that any could proceed from the great abyſs, or that they all returned into it, ſince the great abyſs, according to him, being ſurrounded on every ſide by the cruſt, or terreſtrial orb, it is impoſſible that the attraction of the comet could cauſe any motion to the fluids it contained; much leſs, as he ſays, a violent flux and reflux; hence there could not be iſſued from, nor entered into, the great abyſs, a ſingle drop of water; and unleſs it is ſuppoſed that the waters which fell from the comet have been deſtroyed by a miracle, they would ſtill be on the ſurface of the earth, covering the ſummits of the higheſt mountains. Nothing better characteriſes a miracle, than the impoſſibility of explaining the effect of it by natural cauſes. Our authors have made vain efforts to give a reaſon for the Deluge; their phyſical efforts, and the ſecondary cauſes, which they make uſe of, prove the truth of the fact as reported in the Scriptures, and demonſtrate that it could only have been performed by the firſt cauſe, the will of the Almighty.

Beſides, it is certain that it was neither at one time, nor by the effect of the Deluge, that the ſea left dry theſe continents we inhabit: for it is certain, by the teſtimony of Holy Writ, that the terreſtrial paradiſe was in Aſia, and that Aſia was inhabited before the Deluge; conſequently the ſea, at that time, did not cover this conſiderable part of the globe. The earth before the Deluge was nearly as it is at preſent, and this enormous quantity of water, which divine juſtice cauſed to fall on the earth to puniſh guilty men, in fact, brought death on every creature; but it produced no change on the ſurface of the earth, it did not even deſtroy plants which grew upon it, ſince the dove brought an olive branch to the ark in her beak.

Why, therefore, imagine, as many of our naturaliſts have done, that this water totally changed the ſurface of the globe even to a depth of two thouſand feet? Why do they deſire it to be the Deluge which has brought the ſhells on the earth, which we meet with at 7 or 800 feet depth in rocks and marble? Why ſay, that the hills and mountains were formed at that time? And how can we figure to ourſelves, that it is poſſible for theſe waters to have brought maſſes and banks of ſhells 100 miles long? I ſee not how they can perſiſt in this opinion, at leaſt, without admitting a double miracle in the Deluge; the firſt, for the augmentation of the waters; and the ſecond, for the tranſportation of the ſhells; but as there is only the firſt which is related in the Bible, I do not ſee it neceſſary to make the ſecond an article of our creed.

On the other hand, if the waters of the Deluge had retired all at once, they would have carried ſo great a quantity of mud and other impurities, that the Earth would not have been capable of culture till many ages after this inundation, as is known by the deluge which happened in Greece, where the overflowed country was totally forſaken, and could not receive any cultivation for more than three centuries*. We ought alſo to look on the univerſal Deluge as a ſupernatural means, of which the Almighty made uſe for the chaſtiſement of mankind, and not as an effect of a natural cauſe. The univerſal Deluge is a miracle both in its cauſe and effects; we ſee clearly by the Scripture that it was deſigned for the deſtruction of men and animals, and that it did not in any mode change the earth, ſince after the retreat of the waters, the mountains and even the trees were in their places, and the ſurface of the earth was proper to receive culture, and produce vines and fruits. How could all the race of fiſh, which did not enter the ark, be preſerved, if the earth had been diſſolved in the water, or only if the waters had been ſufficiently agitated to tranſport ſhells from India to Europe, &c.?

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* See Arcta erudit, Lepiſs, Ann. 1691, page 100.

Nevertheleſs, this ſuppoſition, that it was the Deluge which tranſported the ſhells of the ſea into every climate, is the opinion, or rather the ſuperſtition of naturaliſts. Woodward, Scheutzer, and ſome more, call theſe petrified ſhells the remains of the Deluge; they look on them as the medals and monuments which God has left us of this terrible event, in order that it never ſhould be effaced from the human race. In ſhort, they have adopted this hypotheſis with ſo much enthuſiaſm, that they appear only deſirous to reconcile Holy Scripture with their opinion; and inſtead of making uſe of their obſervations, and deriving light therefrom,

from, they envelope themſelves in the clouds of a phyſical theology, the obſcurity of which is derogatory to the ſimplicity and dignity of religion, and only leaves the abſurd to perceive a ridiculous mixture of human ideas and divine truths. To pretend to explain the univerſal Deluge, and its phyſical cauſes; to attempt to teach what paſſed in the time of that great revolution; to divine what were the effects of it; to add facts to thoſe of Holy Writ, to draw conſequences from ſuch facts is only a preſumptuous attempt to meaſure the power of the Moſt High. The natural wonders which his benevolent hand performs in an uniform and regular manner, are incomprehenſible; and by the ſtrongeſt reaſon, theſe wonderful operations and miracles ought to hold us in awful wonder, and in ſilent adoration.

But they will ſay, the univerſal Deluge being a certain fact, is it not permitted to reaſon on its conſequences? It may be ſo; but it is requiſite that you ſhould begin by allowing that the Deluge could not be performed by phyſical cauſes; you ought to conſider it is an immediate effect of the will of the Almighty; you ought to confine yourſelves to know only what the Holy Writ teaches, and particularly not to blend bad philoſophy with the purity of divine truth. Theſe precautions, which the reſpect we owe to the Almighty exacts, being taken, what remains for examination on the ſubject of the Deluge? Does the Scripture ſay mountains were formed by the Deluge? No, it ſays the contrary. Is it ſaid that the agitation of the waters were ſo great, as to raiſe up ſhells from the bottom of the ſea, and tranſport them all over the Earth? No; the ark floated quietly on the ſurface of the waters. Is it ſaid, that the Earth ſuffered a total diſſolution? None at all: the recital of the ſacred hiſtorian is ſimple and true, that of theſe naturaliſts complex and fabulous.

ARTICLE VII.

GEOGRAPHY.

THE ſurface of the Earth, like that of Jupiter, is not divided by bands alternative and parallel to the equator; on the contrary, it is divided from one pole to the other, by two bands of earth, and two of ſea; the firſt and principal is the ancient continent, the greateſt length of which is found to be in a line, beginning on the eaſt point of the northern part of Tartary, and extending from thence to the land which borders on the gulph of Linchidolkin, where the Muſcovites fiſh for whales; from thence to Tobolſki, from Tobolſki to the Caſpian ſea, from the Caſpian ſea to Mecca, and from Mecca to the weſtern part of the country inhabited by the Galli, in Africa; afterwards to Monoemuci or Monomotapa, and at laſt to the Cape of Good Hope; this line, which is the greateſt length of the old continent, is about 3600 leagues, Paris meaſure; it is only interrupted by the Caſpian and Red ſeas, the breadths of which are not very conſiderable, and we muſt not pay any regard to theſe interruptions, when it is conſidered, the ſurface of the globe is divided only in four parts.

This greateſt length is found by meaſuring the old continent diagonally; for if meaſured according to the meridians, we ſhall find that there are only 2500 leagues from the northernmoſt Cape of Lapland to the Cape of Good Hope; and that the Baltic and Mediterranean cauſe a much greater interruption than is met with in the other way. With reſpect to all the other diſtances that might be meaſured in the old continent under the ſam meridian, we ſhall find them to be much ſmaller than this; having, for example, only 1800 leagues from the moſt ſouthern point of the iſland of Ceylon to the northernmoſt coaſt of Nova Zembla. Likewiſe, if we meaſure the continent parallel to the equator, we find that the greateſt uninterrupted length is found from Trefna, on the weſtern coaſt of Africa, to Ninpo, on the eaſtern coaſt of China, and that it is about 2800 leagues. Another courſe may be meaſured from the point of Brittany near Breſt, extending to the Chineſe Tartary; about 2300 leagues. From Bergen, in Norway, to the coaſt of Kamſchatka, is no more than 1800 leagues. All theſe lines have much leſs length than the firſt, therefore the greateſt extent of the old continent, is, in fact from the eaſtern point of Tartary to the Cape of Good Hope, that is about 3600 leagues.

There is ſo great an equality of ſurface on each ſide of this line, which is alſo the longeſt, that there is every probability to ſuppoſe it really divides the contents of the ancient continent; for in meaſuring on one ſide is found 2,471,092¾ ſquare leagues, and on the other 2,469,687.

Agreeable to this, the old continent conſiſts of about 4,940,780 ſquare leagues, which is nearly one-fifth of the whole ſurface of the globe, and has an inclination towards the equator of about 30 degrees.

The greateſt length of the new continent may be taken in a line from the mouth of the river Plata to the lake of the Aſſiniboils. From the former it paſſes to the lake Caracara; from thence to Mataguais, Pocona, Zongo, Mariana, Morua, St. Fe, and Carthagena; it then proceeds through the gulph of Mexico, Jamaica, and Cuba, paſſes along the peninſula of Florida, through Apolache, Chicachas, and from thence to St. Louis, Fort le Suer, and ends on the borders of lake Aſſiniboils; the whole extent of which is ſtill unknown.

This line, which is interrupted only by the Mexican gulph (which muſt be looked upon as a mediterranean ſea) may be about 2500 leagues long, and divides the new continent into nearly two equal parts, the left of which contains about 1,069,286$\frac{5}{6}$ leagues ſquare, and that on the right about 1,070,926$\frac{1}{12}$; this line, which forms the middle of the band of the new continent, is inclined to the equator about 30 degrees, but in an oppoſite direction, for that of the old continent extends from the north-eaſt to the ſouth-weſt, and that of the new continent from the north-weſt to the ſouth-eaſt. All thoſe lands together, of the old and new continent, make about 7,080,993 leagues ſquare, which is not near the third of the whole ſurface, which contains 25 millions of ſquare leagues.

It muſt be remarked, that theſe two lines, which divide the continents into two equal parts, both terminate at the ſame degree of ſouthern and northern latitude, and that the two continents make oppoſite projections, which exactly face each other; to wit, the coaſts of Africa, from the Canary iſlands to the coaſts of Guinea, and thoſe of America from Guiana to the mouth of Rio Janeiro.

It appears, therefore, that the moſt ancient land of the globe is on the two ſides of theſe lines, at the diſtance of from 2 to 250 leagues on each ſide. By following this idea, which is founded on the obſervations before related, we ſhall find in the old continent that the moſt ancient lands of Africa are thoſe which extend from the Cape of Good Hope to the Red Sea, as far as Egypt, about 500 leagues broad, and that, conſequently, all the weſtern coaſts of Africa, from Guinea to the ſtraits of Gibraltar, are the neweſt lands. So likewiſe we ſhall diſcover that in Aſia, if we follow the line on the ſame breadth, the moſt ancient lands are Arabia Felix and Deſerta, Perſia, Georgia, Turcomania, part of Tartary, Circaſſia, part of Muſcovy, &c. that conſequently Europe, and perhaps alſo China, and the eaſtern part of Tartary, are more modern. In the new continent we ſhall find the Terra Magellanica, the eaſtern part of Braſil, the country of the

Amazons, Guiana, and Canada, to be the new lands, in compariſon with Peru, Terra Firma, the iſlands in the gulph of Mexico, Florida, the Miſſiſſippi, and Mexico.

To theſe obſervations we may add two very remarkable facts, the old and new continent are almoſt oppoſite each other; the old is more extenſive to the north of the equator than the ſouth; the new is more to the ſouth than the north. The centre of the old continent is in the 16th or 18th degree of north latitude, and the centre of the new is in the 16th or 18th degree ſouth latitude, ſo that they ſeem to be made to counterbalance each other. There is alſo a ſingular connection between the two continents, although it appears to be more accidental than thoſe which I have ſpoken of, which is, that if the two continents were divided into two parts, all four would be ſurrounded by the ſea, if it were not for the two ſmall iſthmuſes, Suez and Panama.

This is the moſt general idea which an attentive inſpection of the globe furniſhes us with, on the diviſion of the earth. We ſhall abſtain from forming hypotheſes thereon, and hazarding reaſonings which might lead into falſe concluſions; but no one as yet having conſidered the diviſion of the globe under this point of view, I ſhall ſubmit a few remarks. It is very ſingular that the line which forms the greateſt length of the terreſtrial continents divides them alſo into two equal parts; it is no leſs ſo that theſe two lines commence and end at the ſame degrees of latitude, and are both alike inclined to the equator. Theſe relations may belong to ſome general concluſions, but of which we are ignorant. The inequalities in the figure of the two continents we ſhall hereafter examine more fully: it is ſufficient here to obſerve, that the moſt ancient countries are the neareſt to theſe lines, and are the higheſt; that the more modern lands are the fartheſt, and alſo the loweſt. Thus in America, the country of the Amazons, Guiana, and Canada, will be the moſt modern parts; by caſting our eyes on the map of this country we ſee the waters on every ſide, and that they are divided by numberleſs lakes and rivers, which alſo indicates that theſe lands are of a late formation; while, on the other hand, Peru and Mexico are high mountains, and ſituate at no great diſtance from the line that divides the continent, which are circumſtances that ſeem to prove their antiquity. Africa is very mountainous

tainous, and that part of the world is alſo very ancient. There is only Egypt, Barbary, and the weſtern coaſts of Africa, as far as Senegal in this part of the globe, which can be looked upon as modern countries. Aſia is an old land, and perhaps the moſt ancient of all, particularly Arabia, Perſia, and Tartary; but the inequalities of this vaſt part of the globe, as well as thoſe of Europe, we will conſider in a ſeparate article. It might be ſaid, in general, that Europe is a new country, and ſuch poſition would be ſupported both by the univerſal traditions relative to the emigrations of different people, and the origin of arts and ſciences. It is not long ſince it was filled with moraſſes, and covered with foreſts, whereas in the land anciently inhabited, there are but few woods, little water, no moraſſes, much land, and a number of mountains, whoſe ſummits are dry and barren; for men deſtroy the woods, drain the waters, confine rivers, dry up moraſſes, and in time give a different appearance to the face of the earth, from that of uninhabited or newly-peopled countries.

The ancients were acquainted with but a ſmall part of the globe. All America, the Magellanic, and a great part of the interior part of Africa, was entirely unknown to them. They knew not that the torrid zone was inhabited, although they had navigated around Africa, for it is 2200 years ſince Neco, king of Egypt, gave veſſels to the Phenicians, who ſailed along the Red ſea, coaſted round Africa, doubled the Cape of Good Hope, and having employed two years in this voyage, the third year they entered the ſtraits of Gibraltar *. The ancients were unacquainted with the property of the load-ſtone, if turned towards the poles, although they knew that it attracted iron. They were ignorant of the general cauſe of the flux and reflux of the ſea, nor were they certain the ocean ſurrounded the globe; ſome, indeed, ſuſpected it might be ſo, but with ſo little foundation, that no one dared to ſay, or even conjecture, it was poſſible to make a voyage round the world. Magellan was the firſt who attempted it in the year 1519, and accompliſhed the great voyage in 1124 days. Sir Francis Drake was the ſecond, in 1577, and he performed it in 1056 days; afterwards Thomas Cavendiſh made this great voyage in 777 days, in the year 1586. Theſe celebrated navigators were the firſt who demonſtrated

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* Vide Herodotus, lib. iv.

monſtrated phyſically the ſphericity and the extent of the earth's circumference; for the ancients had no conception of the extent of this circumference, although they had travelled a great deal. The trade winds, ſo uſeful in long voyages, were alſo unknown to them; therefore we muſt not be ſurpriſed at the little progreſs they made in geography. Notwithſtanding the knowledge we have acquired by the aid of mathematical ſciences, and the diſcovery of navigators, many things remain ſtill unſettled, and vaſt countries undiſcovered. Almoſt all the land on the ſide of the Atlantic pole is unknown to us; we only know that there is ſome, and that it is ſeparated from all the other continents by the ocean. Much land alſo remains to be diſcovered on the ſide of the Arctic pole, and it is to be regretted that for more than a century the ardour of diſcovering new countries is extremely abated. European governments ſeem to prefer, and poſſibly with reaſon, increaſing the value of thoſe countries we are acquainted with to the glory of conquering new ones.

Nevertheleſs, the diſcovery of the ſouthern continent would be a great object of curioſity, and might be uſeful. We have diſcovered only ſome few of its coaſts; thoſe navigators who have attempted this diſcovery, have always been ſtopped by the ice. The thick fogs, which are in thoſe latitudes, is another obſtacle; yet, in defiance of theſe inconveniencies, it is probable, that by ſailing from the Cape of Good Hope at different ſeaſons, we might at laſt diſcover a part of theſe lands, which hitherto make a ſeparate world.

There is another method which poſſibly might ſucceed better, the ice and fogs having hitherto prevented the diſcovery, might it not be attempted by the Pacific ſea; ſailing from Baldivia, or any other port on the coaſt of Chili, and traverſing this ſea under the 50th degree ſouth latitude; there is not the leaſt appearance that this navigation is perilous, and it is probable would be attended with the diſcovery of new countries; for what remains for us to know on the coaſt of the ſouthern pole, is ſo conſiderable, that we may eſtimate it at a fourth part of the globe, and of courſe may contain a continent as large as Europe, Aſia, and Africa, altogether.

As we are not at all acquainted with this part of the globe, we cannot juſtly know the proportion between the ſurface of the Earth and that of the ſea; only as much as may be judged by inſpection of what is known, there is more ſea than land.

If we would have an idea of the enormous quantity of water which the ſea contains, we muſt ſuppoſe a medium depth, and by computing it only at 200 fathom, or the 6th part of a league, we ſhall find that there is ſufficient to cover the whole globe to the height of 600 feet of water, and if we would reduce this water into one maſs, it would form a globe of more than 60 miles diameter.

Navigators pretend, that the latitudes near the ſouth pole are much colder than thoſe of the north, but there is no appearance that this opinion is founded on truth, and probably has been adopted, becauſe ice is found in latitudes where it is ſcarcely ever ſeen in the ſouthern ſeas; but that may proceed from ſome particular cauſe. We find no ice in April on this ſide 67 and 68 degrees, northern latitude: and the ſavages of Arcadia and Canada ſay, when it is not all melted in that month, it is a ſign the reſt of the year will be cold and rainy. In 1725 there may be ſaid to have been no ſummer, it rained almoſt continually; and the ice of the northern ſea, was not only not melted in April in the 67th degree, but even it was found the 15th of June towards the 41ſt and 42d degree *.

A great quantity of floating ice appears in the northern ſea, eſpecially at ſome diſtance from land. It comes from the Tartarian ſea into that of Nova Zembla, and other parts of the frozen ocean. I have been aſſured by people of credit, that an Engliſh Captain, named Monſon, inſtead of ſeeking a paſſage between the northern land to go to China, directed his courſe ſtrait to the pole, and had approached it within two degrees; that in this courſe he had found an open ſea, without any ice, which proves that the ice is formed near land, and never in open ſea; for if we ſhould ſuppoſe, againſt all probability, that it might be cold enough at the pole to freeze over the ſurface of the ſea, it is ſtill not conceivable how theſe enormous floating mountains of ice could be formed, if they did not find a fixed point againſt land, from whence afterwards they were looſened by the heat of the ſun. The two veſſels which the Eaſt-India Company ſent in 1739, to diſcover land in the South

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* See the Hiſt of the Acad. Ann. 1725.

South ſeas, found ice in the latitude of 47 and 48 degrees, but this ice was not far from ſhore, that being in ſight, although they were unable to land. This muſt have been ſeparated from the adjoining lands of the ſouth pole, and it may be conjectured that they follow the courſe of ſome great rivers, which water the unknown land, the ſame as the Oby, Jeniſca and other great floods, which fall into the north ſeas, carry with them the ice, which, during the greateſt part of the year, ſtops up the ſtraits of Waigat, and renders the Tartarian ſea unnavigable by this courſe; whereas beyond Nova Zembla, and nearer the poles, where there are few rivers, and but little land, ice is not ſo frequently met with, and the ſea is more navigable; ſo that if they would ſtill attempt the voyage to China and Japan by the north ſeas, we ſhould poſſibly, to keep clear from the land and ice, ſhape our courſe to the pole, and ſeek the open ſeas, where certainly there is but little or no ice; for it is known the ſalt water can, without freezing, become colder than freſh water when frozen, and conſequently the exceſſive cold of the pole may poſſibly render the ſea colder than the ice, without the ſurface being frozen: ſo much the more as at 80 or 82 degrees, the ſurface of the ſea, although mixed with much ſnow and freſh water, is only frozen near the ſhore. By collecting the teſtimonies of travellers, on the paſſage from Europe to China, it appears that one does exiſt by the north ſea; and the reaſon it has been ſo often attempted in vain is, becauſe they have always feared to go ſufficiently far from land, and approach the pole.

Captain William Barents, who, as well as others, run aground in his voyage, yet did not doubt but there was a paſſage, and that if he had gone farther from ſhore, he ſhould have found an open ſea free from ice. The Ruſſian navigators, ſent by the Czar to ſurvey the north ſeas, relate that Nova Zembla is not an iſland, but belonging to the continent of Tartary, and that to the north of it is a free and open ſea. A Dutch navigator aſſerts, that the ſea throws up whales on the coaſts of Corea and Japan, which have Engliſh and Dutch harpoons on their backs. Another Dutchman has pretended to have been at the pole, and aſſerts it is as warm there as it is at Amſterdam in the middle of the ſummer. An Engliſhman, named Golding, who made more than thirty voyages to Greenland, related to King Charles II. that two Dutch veſſels with which he had ſailed, having found no whales on the coaſt of the iſland of Edges, reſolved to proceed farther north, and that upon their return, at the expiration of fifteen days, they told him, that they had been as far as 89 degrees latitude (within one degree of the pole), and that they found no ice there, but an open deep ſea like that of the Bay of Biſcay, and that they ſhewed him the journals of the two veſſels, as a proof of what they affirmed. In ſhort, it is related in the Philoſophical Tranſactions that two navigators, who had undertaken the diſcovery of this paſſage, ſhaped a courſe 300 leagues to the eaſt of Nova Zembla, but that the Eaſt India Company, who thought it their intereſt this paſſage ſhould not be diſcovered, hindered them from returning *. But the Dutch Eaſt India Company thought, on the contrary, that it was their intereſt to find this paſſage; having attempted it in vain on the ſide of Europe, they ſought it by that of Japan, and they would probably have ſucceeded, if the Emperor of Japan had not forbidden all ſtrangers from navigating on the ſide of the land of Jeſſo. This paſſage, therefore, cannot

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* See the Collection of Northern Voyages, page 200.

cannot be found but by ſailing to the pole, beyond Spitzbergen, or by keeping the open ſea between Nova Zembla and Spitzbergen under the 79th degree of latitude. We need not fear to find it frozen even under the pole itſelf, for reaſons we have alledged; in fact, there is no example of the ſea being frozen at a conſiderable diſtance from the ſhore; the only example of a ſea being frozen entirely over, is that of the Black Sea, which is narrow, contains but little ſalt, and receives a number of rivers from the northern countries, and which bring ice with them: and if we may credit hiſtorians, it was frozen in the time of the Emperor Copronymus, thirty cubits deep, without reckoning twenty cubits of ſnow above the ice. This appears to be exaggerated, but it is certain that it freezes almoſt every winter; whereas the open ſeas, a thouſand leagues nearer the pole, do not freeze at all; this can only proceed from the ſaltneſs, and the little ice which they receive, in compariſon with that tranſported into the Black Sea.

This ice, which is looked upon as a barrier that oppoſes the navigation near the poles, and the diſcovery of the ſouthern continent, proves only that there are large rivers adjacent to the places where it is met with; and indicates alſo there are vaſt continents from whence theſe rivers flow; nor ought we to be diſcouraged at the ſight of theſe obſtacles; for if we conſider, we ſhall eaſily perceive, this ice muſt be confined to ſome particular places; that it is almoſt impoſſible that it ſhould occupy the whole circle which encompaſſes, as we ſuppoſe, the ſouthern continent, and therefore we ſhould probably ſucceed if we were to direct our courſe towards ſome other point of this circle. The deſcription which Dampier and ſome others have given of New Holland, leads us to ſuſpect that this part of the globe is perhaps a part of the ſouthern lands, and is a country leſs ancient than the reſt of this unknown continent. New Holland is a low country, without water or mountains, but thinly inhabited, and the natives without induſtry; all this concurs to make us think that they are in this continent nearly what the ſavages of Amaconia or Paraguais are in America. We have found poliſhed men, empires, and kings, at Peru and Mexico, which are the higheſt, and conſequently the moſt ancient countries of America. Savages, on the contrary, are found in the loweſt and moſt modern countries;

therefore we may preſume that we ſhould alſo find men united by the bands of ſociety in the upper countries, from whence theſe great rivers, which bring this prodigious ice to the ſea, derive their ſources.

The interior parts of Africa are unknown to us, almoſt as much as they were to the ancients: they had, like us, made the tour of that vaſt peninſula, but they have left us neither charts, nor deſcriptions of the coaſts. Pliny informs us, that the tour of Africa was made in the time of Alexander the Great, that the wrecks of ſome Spaniſh veſſels had been diſcovered in the Arabian ſea, and that Hanno, a Carthagenian general, had made a voyage from Gades to the Arabian ſea, and that he had written a relation of it. Beſides that, he ſays Cornelius Nepos tells us, that in his time one Eudoxus, perſecuted by the king Lathurus, was obliged to fly from his country; that departing from the Arabian gulph, he arrived at Gades, and that before this time they traded from Spain to Ethiopia by ſea *. Notwithſtanding theſe teſtimonies of the ancients, we are perſuaded that they never doubled the Cape of Good Hope, and the courſe which the Portugueſe

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* Vide Pliny, Hiſt. Nat. Vol. 1. lib. 2.

gueſe took the firſt to go to the Eaſt-Indies, was looked upon as a new diſcovery; it will not perhaps, therefore, be deemed amiſs to give the belief of the 9th century on this ſubject.

" In our time an entire new diſcovery has been made, which was wholly unknown to thoſe who lived before us. No one thought, or even ſuſpected, that the ſea, which extends from India to China, had a communication with the Syrian ſea. We have found, according to what I have learnt, in the ſea Roum, or Mediterranean, the wreck of an Arabian veſſel, ſhattered to pieces by the tempeſt, ſome of which were carried by the wind and waves to the Cozar ſea, and from thence to the Mediterranean, and was at length thrown on the coaſt of Syria. This proves that the ſea ſurrounds China and Cila, the extremity of Turqueſton, and the country of the Cozars; that it afterwards flows by the ſtrait till it has waſhed the coaſt of Syria. The proof is drawn from the conſtruction of the veſſel; for no other veſſels but thoſe of Siraf are built without nails, which, as was the wreck we ſpeak of, are joined together in a particular manner, as if they were ſewed. Thoſe, of all the veſſels of the Mediterranean and of the coaſt of Syria, are nailed and not joined in this manner *."

To this the tranſlator of this ancient relation adds,—

"Abuziel remarks, as a new and very extraordinary thing, that a veſſel was carried from the Indian ſea and caſt on the coaſts of Syria. To find a paſſage into the Mediterranean, he ſuppoſes there is a great extent above China, which has a communication with the Cozar ſea, that is, with Muſcovia. The ſea which is below Cape Current, was entirely unknown to the Arabs, by reaſon of the extreme danger of the navigation, and from the continent being inhabited by ſuch a barbarous people, that it was not eaſy to ſubject them, nor even to civilize them by commerce. From the Cape of Good Hope to Soffala, the Portugueſe found no eſtabliſhed ſettlement of Moors, like thoſe in all the maritime towns as far as China, which was the fartheſt place known to geographers; but they could not tell whether the Chineſe ſea, by the extremity of Africa, had a communication with the ſea of Barbary, and they contented themſelves with

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* See the ancient relations of travels by land to China, page 53 and 54.

with deſcribing it as far as the coaſt of Zing, or Caffraria. This is the reaſon why we cannot doubt but that the firſt diſcovery of the paſſage of this ſea, by the Cape of Good Hope, was made by the Europeans, under the conduct of Vaſco de Gama, or at leaſt ſome years before he doubled the Cape, if it is true there are marine charts of an older date, where the Cape is called by the name of Frontiera du Africa. Antonio Galvan teſtifies, from the relation of Franciſco de Souſa Tavares, that, in 1528, the Infant Don Ferdinand ſhewed him ſuch a chart, which he found in the monaſtery of Acoboca, dated 120 years before, copied perhaps from that ſaid to be in the treaſury of St. Mark, at Venice; which alſo marks the point of Africa, according to the teſtimony of Ramuſio, &c."

The ignorance of thoſe ages, on the ſubject of the navigation around Africa, will appear perhaps leſs ſingular than the ſilence of the editor of this ancient relation on the ſubject of the paſſages of Herodotus, Pliny, &c. which we have quoted, and which proves the ancients had made the tour of Africa.

Be it as it may, the African coaſts are now well known ; but whatever attempts have been made to penetrate into the inner parts of the country, we have not been able to attain ſufficient knowledge of it to give exact relations *. It might, nevertheleſs, be of great advantage, if we were, by Senegal, or ſome other river, to get farther up the country and eſtabliſh ſettlements, as we ſhould find, according to all appearances, a country as rich in precious mines as Peru or the Brazils. It is perfectly known that the African rivers abound with gold, and as this country is very mountainous, and ſituated under the equator, it is not to be doubted but it contains, as well as America, mines of heavy metals and of the moſt compact and hard ſtones.

The vaſt extent of north and eaſt Tartary has only been diſcovered in theſe latter times. If the Muſcovite maps are juſt, we are at preſent acquainted with the coaſts of all this part of Aſia; and it appears that from the point of eaſtern Tartary to North America, it is not

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* Since this time, however, great diſcoveries have been made; Monſ. Vaillant has given a particular deſcription of the country from the Cape to the borders of Caffraria; and much information has alſo been acquired by the Society for Aſiatic Reſearches.

more than four or five hundred leagues; it has even been pretended that this tract was much ſhorter, for in the Amſterdam Gazette, of the 24th of January, 1747, it is ſaid, under the article of Peterſburgh, that Mr. Stalleravoit had diſcovered one of theſe American iſlands beyond Kamſchatka, and demonſtrated that we might go thither from Ruſſia by a ſhorter tract. The Jeſuits, and other miſſionaries, have alſo pretended to have diſcovered ſavages in Tartary, whom they had catechiſed in America, which ſhould in fact ſuppoſe that paſſage to be ſtill ſhorter *. This author even pretends, that the two continents of the old and new world join by the north, and ſays, that the laſt navigations of the Japaneſe afford room to judge, that the tract of which we have ſpoken is only a bay, above which we may paſs by land from Aſia to America. But this requires confirmation, for hitherto it has been thought that the continent of the north pole is ſeparated from the other continents, as well as that of the ſouth pole.

Aſtronomy and Navigation are carried to ſo high a pitch of perfection, that it may reaſonably

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* See the Hiſt. of New France, by the Pere Charlevoix, Vol. III. page 30. and 31.

ably be expected we ſhall ſoon have an exact knowledge of the whole ſurface of the globe. The ancients knew only a ſmall part of it, becauſe they had not the mariner's compaſs. Some people have pretended that the Arabs invented the compaſs, and uſed it a long time before we did, to trade on the Indian ſea, as far as China; but this opinion has always appeared deſtitute of all probability; for there is no word in the Arab, Turkiſh, or Perſian languages, which ſignifies the compaſs; they make uſe of the Italian word Boſſola; they do not even at preſent know how to make a compaſs, nor give the magnetical quality to the needle, but purchaſe them from the Europeans. Father Maritini ſays, that the Chineſe have been acquainted with the compaſs for upwards of 3000 years; but if that was the caſe, how comes it that they have made ſo little uſe of it? Why did they, in their voyages to Cochinchina, take a courſe much longer than was neceſſary? And why did they always confine themſelves to the ſame voyages, the greateſt of which were to Java and Sumatra? And why did not they diſcover, before the Europeans, an infinity of fertile iſlands, bordering on their own country, if they had poſſeſſed the art of navigating in the open ſeas? For a few years after the diſcovery of this wonderful property of the loadſtone, the Portugueſe doubled the Cape of Good Hope, traverſed the African and Indian ſeas, and Chriſtopher Columbus made his Voyage to America.

By a little conſideration, it was eaſy to divine there were immenſe ſpaces towards the weſt; for, by comparing the known part of the globe, as for example, the diſtance of Spain to China, and attending to the revolution of the Earth and Heavens, it was eaſy to ſee that there remained a much greater extent towards the weſt to be diſcovered, than what they were acquainted with towards the eaſt. It, therefore, was not from the defect of aſtronomical knowledge that the ancients did not find the new world, but only for want of the compaſs. The paſſages of Plato and Ariſtotle, where they ſpeak of countries far diſtant from the pillars of Hercules, ſeem to indicate that ſome navigators had been driven by tempeſt as far as America, from whence they returned with much difficulty; and it may be conjectured, that if even the ancients had been perſuaded of the exiſtence of this continent, they would not have even thought it poſſible to ſtrike out the road, having no guide nor any knowledge of the compaſs.

I own, that it is not impoſſible to traverſe the high ſeas without a compaſs, and that very reſolute people might have undertaken to ſeek after the new world by conducting themſelves ſimply by the ſtars. The Aſtrolabe being known to the ancients, it might ſtrike them they could leave France or Spain, and ſail to the weſt by keeping the polar ſtar always to the right, and by frequent ſoundings might have kept nearly in the ſame latitude; without doubt the Carthagenians, of whom Ariſtotle makes mention, found the means of returning from theſe remote countries, by keeping the polar ſtar to the left; but it muſt be allowed that a like voyage would be looked upon as a raſh enterprize, and that conſequently we muſt not be aſtoniſhed that the ancients have not even conceived the project.

Previous to Chriſtopher Columbus's expedition, the Azores, the Canaries, and Madeira, were diſcovered. It was remarked, that when the weſt winds laſted a long time, the ſea brought pieces of foreign wood on the coaſt of theſe iſlands, canes of unknown ſpecies, and even dead bodies, which by many marks were diſcovered to be neither European nor African. Columbus himſelf remarked, that on the ſide of the weſt certain winds blew only a few days, and which he was perſuaded were land winds; but although he had all theſe advantages over the ancients, and the knowledge of the compaſs, the difficulties ſtill to conquer were ſo great, that there was only the ſucceſs he met with which could juſtify the enterpriſe. Suppoſe, for a moment, that the continent of the new world had been 1000 or 1500 miles farther than it in fact is, a thing which Columbus could neither know nor foreſee, he would not have arrived there, and perhaps this great country might ſtill have remained unknown. This conjecture is ſo much the better founded, as Columbus, although the moſt able navigator of his time, was ſeized with fear and aſtoniſhment in his ſecond voyage to the new world; for as in his firſt he only found ſome iſlands, he directed his courſe more to the ſouth to diſcover a continent, and was ſtopt by currents, the conſiderable extent and direction of which always oppoſed his courſe, and obliged him to direct his ſearch to the weſt; he imagined that what had hindered him from advancing on the ſouthern ſide was not currents, but that the ſea flowed by raiſing itſelf towards the heavens, and that perhaps both one and the other touched on the ſouthern ſide. True it is, that in great enterpriſes the leaſt unfortunate circumſtance may turn a man's brain, and abate his courage.

ARTICLE VII.

ON THE PRODUCTION OF THE STRATA, OR BEDS OF EARTH.

WE have ſhewn, in the firſt article, that by virtue of the mutual attraction between the parts of matter, and of the centrifugal force, which reſults from its diurnal rotation, the earth has neceſſarily taken the form of a ſpheroid, the diameters of which differ about a

230th part, and that it could only proceed from the changes on the ſurface, cauſed by the motion of the air and water, that this difference could become greater, as is pretended to be the caſe from the meaſures taken under the equator, and within the polar circle. This figure of the Earth, which ſo well agrees with hydroſtatical laws, and with our theory, ſuppoſes the globe to have been in a ſtate of liquefaction when it aſſumed its form, and we have proved that the motion of projection and rotation were imprinted at the ſame time by a like impulſion. We ſhall the more eaſily believe that the earth has been in a ſtate of liquefaction produced by fire, when we conſider the nature of the matters which the globe incloſes, the greateſt part of which are vitrified or vitrifiable; eſpecially when we reflect on the impoſſibility there is that the earth ſhould ever have been in a ſtate of fluidity, produced by the waters; ſince there is infinitely more earth than water, and that water has not the power of diſſolving ſtone, ſand, and other matters of which the earth is compoſed.

It is plain then that the earth took its figure at the time when it was liquefied by fire: by purſuing our hypotheſis it appears, that when the ſun quitted it, the earth had no other form than that of a torrent of melted and inflamed vapour matter; that this torrent collected itſelf by the mutual attraction of its parts, and became a globe, to which the rotative motion gave the figure of a ſpheroid; and when the earth was cooled, the vapours, which were firſt extended like the tails of comets, by degrees condenſed and fell upon the ſurface, depoſiting, at the ſame time, a ſlimy ſubſtance mixed with ſulphurous and ſaline matters, a part of which, by the motion of the waters, was ſwept into the perpendicular cracks where it produced metals, while the reſt remained on the ſurface, and produced that reddiſh earth which forms the firſt ſtrata; and which, according to different places, is more or leſs blended with animal vegetable particles, ſo reduced that the organization is no longer perceptible.

Therefore, in the firſt ſtate of the earth, the globe was internally compoſed of vitrified matter, as I believe it is at preſent, above which were placed thoſe bodies the fire had moſt divided, as ſand, which are only fragments of glaſs, and above theſe pumice ſtones, and the ſcoria of the vitrified matter, which formed the various clays; the whole was covered with water 5 or 600 feet deep, produced by the condenſation of the vapours when the globe began to cool. This water every where depoſited a muddy bed mixed with matters which ſublime and exhale by the fire ; and the air was formed of the moſt ſubtile vapours which, by their lightneſs, diſengaged themſelves from the waters and ſurmounted them.

Such was the ſtate of the globe when the action of the tides, the winds and the heat of the ſun, began to change the ſurface of the earth. The diurnal motion, and the flux and reflux, at firſt raiſed the waters under the ſouthern climate, which carried with them mud, clay, and ſand, and by raiſing the parts of the equator, they by degrees perhaps lowered thoſe of the poles about two leagues, as we before mentioned ; for the waters ſoon reduced into powder the pumice ſtones and other ſpongeous parts of the vitrified matter that were at the ſurface, they hollowed ſome places, and raiſed others, which in courſe of time became continents, and produced all the inequalities, and which are more conſiderable towards the equator than the poles ; for the higheſt mountains are between the tropics and the middle of the temperate zones, and the loweſt are from the polar circle to the poles; between the tropics are the Cordeliers, and almoſt all the mountains of Mexico and Brazil, the great and little Atlas, the Moon, &c. Beſide the land which is between the tropics, from the ſuperior number of iſlands found in thoſe parts, is the moſt unequal of all the globe, as evidently is the ſea.

However independent my theory may be of that hypotheſis of what paſt at the time of the firſt ſtate of the globe, I refer to it in this article, in order to ſhew the connection and poſſibility of the ſyſtem which I endeavoured to maintain in the firſt article. It muſt only be remarked, that my theory does not ſtray far from it, as I take the earth in a ſtate nearly ſimilar to what it appears at preſent, and as I do not make uſe of any of the ſuppoſitions which are uſed in reaſoning on the paſt ſtate of the terreſtrial globe. But as I here preſent a new idea on the ſubject of the ſediment depoſited by the water, which, in my opinion, has perforated the upper bed of earth, it appears to me alſo neceſſary to give the reaſon on which I found this opinion.

The vapours which riſe in the air produce rain, dew, aerial fires, thunder, and other meteors. Theſe vapours are therefore blended with aqueous, aerial, ſulphurous and terreſtrial particles, &c. and it is the ſolid and earthy particles which form the mud or ſlime we are now ſpeaking of. When rain water is ſuffered to reſt, a ſediment is formed at bottom; and having collected a quantity, if it is ſuffered to ſtand and corrupt, it produces a kind of mud which falls to the bottom of the veſſel. Dew produces much more of this mud than rain water, which is greaſy, unctious, and of a reddiſh colour.

The firſt ſtrata of the earth is compoſed of this mud mixed with periſhed vegetable or animal parts, or rather ſtony and ſandy particles. We may remark that almoſt all land proper for cultivation is reddiſh, and more or leſs mixed with theſe different matters; the particles of ſand or ſtone found there are of two kinds, the one coarſe and heavy, the other fine and ſometimes impalpable. The largeſt comes from the lower ſtrata looſened in cultivating the earth, or rather the upper mould, by penetrating into the lower, which is of ſand and other divided matters, and forms thoſe earths we call fat and fertile. The finer ſort proceeds from the air, and falls with dew and rain, and mixes intimately with the ſoil. This is properly the reſidue of the powder which the wind continually raiſes from the ſurface of the earth, and which falls again after having imbibed the humidity of the air. When the earth predominates, and the ſtony and ſandy parts are but few, the earth is then reddiſh and fertile: if it is mixed with a conſiderable quantity of periſhed animal or vegetable ſubſtances, it is blackiſh, and often more fertile than the firſt; but if the mould is only in a ſmall quantity, as well as the animal or vegetable parts, the earth is white and ſterile, and when the ſandy, ſtony, or cretaceous parts which compoſe theſe ſterile lands, are mixed with a ſufficient quantity of periſhed animal or vegetable ſubſtances, they form the black and lighter earths, but have little fertility; ſo that according to the different combinations of theſe three different matters, the land is more or leſs fecund and differently coloured.

To fix ſome ideas relative to theſe ſtratas; let us take, for example, the earth of Marly-la-ville, where the pits are very deep: it is a high country, but flat and fertile, and its ſtrata lie arranged horizontally. I had ſamples brought me of all theſe ſtrata which M. Dalibard, an able Botaniſt, verſed in different ſciences, had dug under his inſpection; and after having proved the matters of which they conſiſted in aquafortis, I formed the following table of them.

The ſtate of the different beds of earth, found at Marly-la-Ville, to the depth of 100 feet.

	Feet.	In.
1. A free reddiſh earth, mixed with much mud, a very ſmall quantity of vitrifiable ſand, and ſomewhat more of calcinable ſand - - - - - - -	13	0
2. A free earth mixed with gravel, and a little more vitrifiable ſand - -	2	6
3. Mud mixed with vitrifiable ſand in a great quantity, and which made but very little efferveſcence with aquafortis - - - - - - - - - -	3	0
4. Hard marl, which made a very great efferveſcence with aquafortis -	2	0
5. Pretty hard marly ſtone - -	4	0
6. Marl in powder, mixed with vitrifiable ſand - - - - - - - -	5	0
7. Very fine vitrified ſand - - -	1	6
8. Marl very like earth mixed with a very little vitrifiable ſand - - -	3	6
Carried over -	34	6

	Feet.	In.
Brought over	34	6
9. Hard marl, in which was real flint	3	6
10. Gravel, or powdered marl	1	0
11. Eglantine, a ſtone of the grain and hardneſs of marble, and ſonorous	1	6
12. Marly gravel	1	6
13. Marl in hard ſtone, whoſe grain was very fine	1	6
14. Marl in ſtone, whoſe grain was not ſo fine	1	6
15. More grained and thicker marl	2	6
16. Very fine vitrifiable ſand, mixed with foſſil ſea-ſhells, which had no adherence with the ſand, and whoſe colours were perfect	1	6
17. Very ſmall gravel, or fine marl powder	2	0
18. Marl in hard ſtone	3	6
19. Very coarſe powdered marl	1	6
20. Hard and calcinable ſtone, like marble	1	0
21. Grey vitrifiable ſand mixed with foſſil ſhells, particularly oyſters and muſcles, which have no adherence		
Carried over	57	0

	Feet.	In.
Brought over	57	0
with the ſand, and which were not petrified	3	0
22. White vitrifiable ſand mixed with ſimilar ſhells	2	0
23. Sand ſtreaked red and white, vitrifiable and mixed with the like ſhells	1	0
24. Larger ſand, but ſtill vitrifiable and mixed with the like ſhells	1	0
25. Fine and vitrifiable grey ſand mixed with the like ſhells	8	6
26. Very fine fat ſand, with only a few ſhells	3	0
27. Brown free ſtone	3	0
28. Vitrifiable ſand, ſtreaked red and white	4	0
29. White vitrifiable ſand	3	6
30. Reddiſh vitrifiable ſand	15	0
Total depth	101	0

I have before ſaid that I tried all theſe matters in aquafortis, becauſe where the inſpection and compariſon of matters with others that we are acquainted with is not ſufficient to permit us to denominate and range them in the claſs which they belong, there is no means more ready, nor perhaps more ſure, than to try by aquafortis the terreſtrial or lapidific matter: thoſe which acid ſpirits diſſolve immediately with heat and ebullition are generally calcinable, and thoſe on which they make no impreſſion are vitrifiable.

By this enumeration we perceive, that the ſoil of Marly-la-Ville was formerly the bottom of the ſea, which has been raiſed above 75 feet, ſince we find ſhells at that depth below the ſurface. Thoſe ſhells have been tranſported by the motion of the water, at the ſame time as the ſand in which they are met with, and the whole of the upper ſtrata, even to the firſt, have been tranſported after the ſame manner by the motion of the water, and depoſited in form of a ſediment; which we cannot doubt, as well by reaſon of their horizontal poſition, as of the different beds of ſand mixed with ſhells and marl, the laſt of which are only the fragments of ſhells. The laſt ſtratum itſelf has been formed almoſt entirely by the mould we have ſpoken of, mixed with a ſmall part of the marl which was at the ſurface.

I have choſen this example, as the moſt diſadvantageous to my theory, becauſe it at firſt appears very difficult to conceive that the duſt of the air, rain and dew, could produce ſtrata of free earth thirteen feet thick; but it ought to be obſerved, that it is very rare to find, eſpecially in high lands, ſo conſiderable a thickneſs of cultivateable earth; it is generally about three or four feet, and often not more than one. In plains ſurrounded with hills, this thickneſs of good earth is the greateſt, becauſe the rain looſens the earth of the hills, and carries it into the vallies; but without ſuppoſing any thing of that kind, I find that the laſt ſtrata formed by the waters are thick beds of marl. It is natural to imagine that the upper ſtratum had, at the beginning, a ſtill greater thickneſs, beſides the thirteen feet of marl, when the ſea quitted the land and left it naked. This marl, expoſed to the air, melted with the rain; the action of the air and heat of the ſun produced flaws, and reduced it into powder on the ſurface; the ſea would not quit this land precipitately, but ſometimes cover it, either by the alternative motion of the tides, or by the extraordinary elevation of the waters in foul weather, when it mixed with this bed of marl, mud, clay, and other matters. When the land was raiſed above the waters, plants would begin to grow, and it was then that the duſt in the rain or dew by degrees added to its ſubſtance and gave it a reddiſh colour; this thickneſs and fertility was ſoon augmented by culture; by digging and dividing its ſurface, and thus giving to the duſt, in the dew or rain, the facility of more deeply penetrating it, which at laſt produced that bed of free earth thirteen feet thick.

I ſhall not here examine whether the reddiſh colour of vegetable earth proceeds from the iron which is contained in the earths that are depoſited by the rains and dews, but being of importance, ſhall take notice of it when we come to treat of minerals; it is ſufficient to have explained our conception of the formation of the ſuperficial ſtrata of the earth, and by other examples we ſhall prove, that the formation of the interior ſtrata, can only be the work of the waters.

The ſurface of the globe, ſays Woodward, this external ſtratum on which men and animals walk, which ſerves as a magazine for the formation of vegetables and animals, is, for the greateſt part, compoſed of vegetable or animal matter, and is in continual motion and variation. All animals and vegetables which have exiſted from the creation of the world, have ſucceſſively extracted from this ſtratum the matter which compoſes it, and have, after their deaths, reſtored to it this borrowed matter: it remains there always ready to be retaken, and to ſerve for the formation of other bodies of the ſame ſpecies ſucceſſively, for the matter which compoſes one body is proper and natural to form another body of the ſame kind. In uninhabited countries, where the woods are never cut, where animals do not brouze on the plants, this ſtratum of vegetable earth increaſes conſiderably. In all woods, even in thoſe which are ſometimes cut, there is a bed of mould, of ſix or eight inches thick, formed entirely by the leaves, ſmall branches, and barks which have periſhed. I have often obſerved on the ancient Roman way, which croſſes Burgundy in a long extent of ſoil, that there is formed a bed of black earth more than a foot thick upon the ſtones, which nouriſhes very high trees; and this ſtratum could be compoſed only of a black mould formed by the leaves, bark, and periſhed wood. As vegetables inhale for their nutriment much more from the air and water than the earth, it happens that when they periſh, they return to the earth more than they have taken from it. Beſides, foreſts collect the rain water, and by ſtopping the vapours increaſe their moiſture; ſo in a wood which is preſerved a long time, the ſtratum of earth which ſerves for vegetation increaſes conſiderably. But animals reſtoring leſs to the earth than they take from it, and men making enormous conſumption of wood and plants for fire and other uſes, it follows that the vegetable ſoil of inhabited countries muſt diminiſh, and become, in time, like the ſoil of Arabia, Petrea, and other eaſtern provinces, which, in fact, are the moſt ancient inhabited countries, where only ſand and ſalt is now to be met with; for the fixed ſalts of plants and animals remain, whereas all the other parts volatiliſe, and are tranſported by the air.

Let us now examine the poſition and formation of the interior ſtrata: the earth, ſays Woodward, appears in places that have been dug, compoſed of ſtrata placed one on the other, as ſo many ſediments which neceſſarily fell to the bottom of the water; the deepeſt ſtrata are generally the thickeſt, and thoſe above the thinneſt, and ſo gradually leſſening to the

the ſurface. We find ſea ſhells, teeth, and bones of fiſh in theſe different beds, and not only in thoſe that are ſoft, as chalk and clay, but even in thoſe of hard ſtone, marble, &c. Theſe marine productions are incorporated with the ſtone, and when ſeparated from them, leave the impreſſions of the ſhells with the greateſt exactneſs. "I have been moſt clearly and poſitively aſſured," ſays this author, "that in France, Flanders, Holland, Spain, Italy, Germany, Denmark, Norway, and Sweden, ſtone, and other terreſtrial ſubſtances are diſpoſed in ſtrata, preciſely the ſame as they are in England; that theſe ſtrata are divided by parallel fiſſures; that there are incloſed within ſtones and other terreſtrial and compact ſubſtances, a great quantity of ſhells and other productions of the ſea, diſpoſed in the ſame manner as in this Iſland. I am alſo informed that theſe ſtrata are found the ſame in Barbary, Egypt, Guinea, and in other parts of Africa; in Arabia, Syria, Perſia, Malabar, China, and the reſt of the provinces of Aſia; in Jamaica, Barbadoes, Virginia, New-England, Brazil, and other parts of America*."

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* Eſſay on the Natural Hiſtory of the Earth, page 40, 41, 42, &c.

This author does not ſay how he learnt, or by whom he was told, that the ſtrata of Peru contained ſhells; yet as in general his obſervations are exact, I do not doubt but he was well informed; and am perſuaded that ſhells may be found in the earth of Peru, as well as elſewhere. This remark is made from a doubt having been formed ſome time ſince on the ſubject, and which I ſhall hereafter conſider.

In a trench made at Amſterdam, to the depth of 230 feet, the ſtrata were found as follows: 7 feet of vegetable earth, 9 of turf, 9 of ſoft clay, 8 of ſand, 4 of earth, 10 of clay, 4 of earth, 10 of ſand, then 2 feet clay, 4 of white ſand, 5 of dry earth, 1 of ſoft earth, 14 of ſand, 8 of argil, mixed with earth; 4 of ſand, mixed with ſhells; then clay 102 feet thick, and at laſt 31 feet of ſand, at which depth they ceaſed digging *.

It is very ſingular to dig ſo deep without meeting with water: and this circumſtance is remarkable in many particulars. 1. It ſhews, that the water of the ſea does not communicate with the interior part of the earth, by means of filtration. 2. That ſhells are found at the depth of 100 feet below the ſurface, and that conſequently

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* See Varennii, Geograph. General, page 46.

conſequently the ſoil of Holland has been raiſed 100 feet by the ſediment of the ſea. 3. We may draw an induction, that this ſtrata of thick clay of 102 feet, and the bed of ſand below it, in which they dug to 31 feet, and whoſe entire thickneſs is unknown, are perhaps not very far diſtant from the firſt ſtrata of the original earth, ſuch as it was before the motion of the water had changed its ſurface. We have ſaid in the firſt article, that if we deſired to find the ancient earth, we ſhould dig in the northern countries, rather than towards the ſouth; in plains, rather than in mountainous regions. The circumſtances in this inſtance, appear to be nearly ſo, only it is to be wiſhed they had continued the digging to a greater depth, and that the author had informed us, whether there were not ſhells and other marine productions, in the laſt bed of clay, and in that of ſand below it. The experiment confirms what we have already ſaid; and the more we dig, the greater thickneſs we ſhall find the ſtrata.

The earth is compoſed of parallel and horizontal beds, not only in plains, but hills and mountains are in general compoſed after the ſame manner: it may be ſaid, that the ſtrata in hills and mountains are more apparent there than in the plains, becauſe the plains are generally covered with a very conſiderable quantity of ſand and earth, which the water has brought from the higher grounds, and therefore, to find the ancient ſtrata, we muſt dig deeper in the plains than in the mountains.

I have often obſerved, that when a mountain is level at its ſummit, the ſtrata, which compoſe it are alſo level; but if the ſummit is not placed horizontally, the ſtrata inclines alſo in the ſame direction. I have heard that, in general the beds of quarries inclined a little to the eaſt, but having myſelf obſerved all the chains of rocks which offered, I diſcovered this opinion to be erroneous, and that the ſtrata inclines to the ſame ſide as the hill, whether it be eaſt, weſt, north, or ſouth. When we dig ſtone and marble from the quarry, we take great care to ſeparate them according to their natural poſition, and we cannot even get them of a large ſize, if we cut them in any other direction. Where they are made uſe of for good maſonry, the workmen are particular in placing them as they ſtood in the quarry, for if they were placed in any other direction, they would ſplit, and would not reſiſt the weight with which they are loaded. This perfectly confirms that ſtones are found in parallel and horizontal ſtrata, which have been ſucceſſively heaped one on the other, and that theſe ſtrata compoſed maſſes where reſiſtance is greater in that direction than in any other.

Every ſtrata, whether horizontal or inclined, has an equal thickneſs throughout its whole extent. In the quarries about Paris, the bed of good ſtone is not thick, ſcarcely more than 18 or 20 feet: in thoſe of Burgundy the ſtone is much thicker. It is the ſame with marble; the black and white marble have a thicker bed than the coloured; and I know beds of very hard ſtone, which the farmers in Burgundy make uſe of to cover their houſes, that are not above an inch thick. The different ſtrata vary much in thickneſs, but each bed preſerves the ſame thickneſs throughout its extent. The thickneſs of ſtrata is ſo greatly varied, that it is found from leſs than a line to 1, 10, 20, 30, or 100 feet thick. The ancient and modern quarries, which are horizontally dug, the perpendicular and other diviſions of mines, prove that there are extenſive ſtrata in all directions. "It is thoroughly proved," ſays the hiſtorian of the academy, "that all ſtones have formerly been a ſoft paſte, and as there are quarries almoſt in every part, the ſurface of the earth has therefore conſiſted, in all theſe places, of mud and ſlime, at leaſt to certain depths. The ſhells found in moſt quarries prove that this mud was an earth diluted by the water of the ſea, and conſequently that the ſea covered all theſe places ; and it could not cover them without alſo covering all that was level with or lower than it: and it is plain that it could not cover every place where there were quarries, without covering the whole face of the terreſtrial globe. We do not here conſider the mountains which the ſea muſt alſo at one time have covered, ſince quarries and ſhells are often found in them.

"The ſea," continues he, "therefore, covered the whole earth, and from thence it proceeds that all the beds of ſtone in the plains are horizontal and parallel: fiſh muſt have alſo been the moſt ancient inhabitants of the globe, as there was no ſuſtenance for either birds or terreſtrial animals. But how did the ſea retire into theſe vaſt baſons which it at preſent occupies? What preſents itſelf the moſt natural to the mind is, that the earth, at leaſt at a certain depth, was not entirely ſolid, but intermixed with ſome great vacuums, whoſe vaults were ſupported for a time, but at length ſunk in ſuddenly: then the waters muſt have fallen into theſe vacancies, filled them, and left naked a part of the earth's ſurface, which became an agreeable abode to terreſtrial animals and birds. The ſhells found in quarries perfectly agree with this idea, for only the bony parts of fiſh could be preſerved till now. In general, ſhells are heaped up in great abundance in certain parts of the ſea, where they are immoveable, and form a kind of rock, and could not follow the water, which ſuddenly forſook them: this is the reaſon that we find more ſhells than bones of the fiſh, and this even proves a ſudden fall of the ſea into its preſent baſons. At the ſame time as our ſuppoſed vaults gave way, it is very poſſible that other parts of the globe were raiſed by the ſame cauſe, and that mountains were placed on this ſurface with quarries already formed, but the beds of theſe quarries could not preſerve the horizontal direction they before had, unleſs the mountains were raiſed preciſely perpendicular to the ſurface of the earth, which could happen but very ſeldom: ſo alſo, as we have already obſerved, in 1705, the beds of ſtone in mountains are always inclined to the horizon, though parallel with each other; for they have not changed their poſition with reſpect to each other, but only with reſpect to the ſurface of the earth *.

Theſe parallel ſtrata, theſe beds of earth and ſtone, which have been formed by the ſediment of the ſea, often extend to conſiderable diſtances, and we often find in hills, ſeparated by a valley, the ſame beds, and the ſame matters at the ſame level. This obſervation agrees perfectly with that of the height of the oppoſite hills. We may eaſily be aſſured of the truth of theſe facts, for in all narrow vallies, where rocks are diſcovered, we ſhall find the ſame beds of ſtone and marble on both ſides at the ſame height. In a country where I frequently reſide, I found a quarry of marble which extended more than 12 leagues in length, and whoſe breadth was very conſiderable, although I have never been able preciſely to determine it. I have often obſerved that this bed of marble is throughout of the ſame thickneſs, and in hills divided from this quarry by a valley of 100 feet depth, and a quarter of a mile in breadth, I found the ſame bed of marble at the ſame height. I am perſuaded it

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* See the Mem. of the Acad. 1716, page 14.

it is the ſame in every ſtone and marble quarry, where ſhells are found; but this obſervation does not hold good in quarries of free ſtone. In the courſe of this work, we ſhall give reaſons for this difference, and deſcribe why freeſtone is not diſperſed, like other matters, in horizontal beds, and why it is in irregular blocks, both in form and poſition.

We have likewiſe obſerved, that the ſtrata are the ſame on both ſides the ſtraits of the ſea. This obſervation, which is important, may lead us to diſcover the lands and iſlands which have been ſeparated from the continent; it proves, for example, that England has been divided from France; Spain from Africa; Sicily from Italy, and it is to be wiſhed that the ſame obſervation had been made in all the ſtraits. I am perſuaded that we ſhould find it almoſt every where true. We do not know whether the ſame beds of ſtone are found at the ſame height on both ſides the ſtraits of Magellan, which is the longeſt; but we ſee, by the particular maps and exact charts, that the two high coaſts which confine it, form nearly, like the mountains of the earth, correſpondent angles, which alſo proves that the Terra del Fuega, muſt be regarded as part of the continent of

America; it is the ſame with Forbiſher's Strait and the iſland of Frieſland, which appear to have been divided from the continent of Greenland.

The Maldivian iſlands are only ſeparated by ſmall tracts of the ſea, on each ſide of which banks and rocks are found compoſed of the ſame materials; and theſe iſlands, which, taken together, are near 200 miles long, formed anciently only one land; they are now divided into 13 provinces, called Cluſters. Each cluſter contains a great number of ſmall iſlands, moſt of which are ſometimes overflowed, and ſometimes dry; but what is remarkable, theſe thirteen cluſters are each ſurrounded with a chain of rocks of the ſame ſtone, and there are only three or four dangerous inlets, by which they can be entered. They are all placed one after the other, and it evidently appears that theſe iſlands were formerly a long mountain capped with rocks*.

Many authors, as Verſtegan, Twine, Somner, and eſpecially Campbell, in his Deſcription of England, in the Chapter of Kent, gives very ſtrong reaſons, to prove that England was formerly joined to France, and has been ſeparated from it by an effort of the ſea, which carried away the neck of land that joined them, opened the Channel, and left naked a great quantity of low and marſhy ground along the ſouthern coaſts of England. Dr. Wallis, as a corroboration of this ſuppoſition, ſhews the conformity of the ancient Gallic and Britiſh tongues, and adds many obſervations, which we ſhall relate in the following articles.

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* See the Voyages of Francis Piriard, vol. 1, page 108.

If we conſider the form of lands, the poſition of mountains, and the windings of rivers, we ſhall perceive that generally oppoſite hills are not only compoſed of the ſame matters on the ſame level, but are nearly of an equal height. This equality I have obſerved in my travels, and have moſtly found them the ſame on the two ſides, eſpecially in vallies that were not more than a quarter or a third of a league broad, for in vallies which are very broad, it is difficult to judge of the height and equality of hills, becauſe by looking over a level plain of any great extent, it appears to riſe, and hills at a diſtance appear to lower; but this is not the place to give a mathematical reaſon for this difference. It is alſo very difficult to judge, by the naked ſight of the middle of a great valley, at leaſt if there is no river in it; whereas in confined vallies our ſight is leſs equivocal and our judgment more certain. That part of Burgundy comprehended between Auxerre, Dijon, Autun, and Bar-ſur-ſeine, a conſiderable extent of which is called *la Bailliage de la Montagne*, is one of the higheſt parts of France ; from one ſide of moſt of theſe mountains, which are only of the ſecond claſs, the water flows towards the Ocean, and on the other ſide towards the Mediterranean. This high country is divided with many ſmall vallies, very confined, and almoſt all watered with rivulets. I have a thouſand times obſerved the correſpondence of the angles of theſe hills and their equality of height, and I am certain that I have every where found the ſaliant angles oppoſite to the returning angles, and the heights nearly equal on both ſides. The farther we advance into the higher country, where the points of diviſion are, the higher are the mountains; but this height is always the ſame on both ſides of the vallies, and the hills are raiſed or lowered alike. I have frequently made the like obſervations in many other parts of France. It is this equality in the height of the hills which forms the plains in the mountains, and theſe plains form lands higher than others. But high mountains do not appear ſo equal in height, moſt of them terminate in points and irregular peaks, and I have ſeen, in croſſing the Alps and the Appenine mountains, that the angles are, in fact, correſpondent; but it is almoſt impoſſible to judge by the eye of the equality or inequality in the height of oppoſite mountains, becauſe their ſummits are loſt in miſts and clouds.

The different ſtrata of which the earth is compoſed, are not diſpoſed according to their ſpecific weight, for we often find ſtrata of heavy matters placed on thoſe of lighter. To be aſſured of this, we have only to examine the earth on which rocks are placed, and we ſhall find that it is generally clay or ſand, which is ſpecifically lighter. In hills, and other ſmall elevations, we eaſily diſcover this to be the caſe; but it is not ſo with large mountains, for not only their ſummits are rocks, but thoſe rocks are placed on others; there mountains are placed upon mountains, and rocks upon rocks, to ſuch a conſiderable height, and through ſo great an extent of country, that we can ſcarcely be certain whether there is earth at bottom, or of what nature it is. I have ſeen cavities made in rocks to ſome hundred feet deep, without being able to form an idea where they ended, for theſe rocks were ſupported by others: nevertheleſs, may we not compare great with ſmall? and ſince the rocks of little mountains, whoſe baſes are to be ſeen, reſt on the earth leſs heavy and ſolid than ſtone, may we not ſuppoſe that earth is alſo the baſe [illegible] high mountains Al that I have here to prove by theſe arguments is, that by the motion of the waters, it may naturally happen that the more ponderous matters accumulated on the lighter; and, that if this in fact is found to be ſo in moſt hills, it is probable that it happened as explained by my theory; but ſhould it be objected that I am not grounded in ſuppoſing, that before the formation of mountains the heavieſt matters were below the lighter; I anſwer, that I aſſert nothing general in this reſpect, becauſe this effect may have been produced in many manners, whether the heavieſt matters were uppermoſt or undermoſt, or placed indiſcriminately. To conceive how the ſea at firſt formed a mountain of clay, and afterwards capt it with rocks, it is ſufficient to conſider the ſediments may ſucceſſively come from different parts, and that they might be of different materials. In ſome parts the ſea may at firſt have depoſited ſediments of clay, and the waters afterwards brought ſediment of ſtrong matter, either becauſe they had tranſported all the clay from the bottom and ſides, and then the waves attacked the rocks, or poſſibly becauſe the firſt ſediment came from one part, and the ſecond from another. This perfectly agrees with obſervation, by which we perceive that beds of earth, ſtone, gravel, ſand, &c. follow no rule in their arrangement, but are placed indifferently one on the other as it were by chance.

But this chance muſt have ſome rules, which can be known only by eſtimating the value of probabilities, and the truth of conjectures. According to our hypotheſis, on the formation of the globe, we have ſeen that the interior part of the globe muſt have been a vitrified matter, ſimilar to vitrified ſand, which is only the fragments of glaſs, and of which the clays are perhaps the ſcoria; by this ſuppoſition, the centre of the earth, and almoſt as far as the external circumference, muſt be glaſs, or a vitrified matter: and above this we ſhould find ſand, clay, and other ſcoria. Thus the earth, in its firſt ſtate, was a nucleus of glaſs, or vitrified matter; either maſſive like glaſs, or divided like ſand, becauſe that depends on the degree of heat it has undergone. Above this matter was ſand, and laſtly clay. The ſoil of the waters and air produced the external cruſt, which is thicker or thinner according to the ſituation of the ground; more or leſs coloured, according to the different mixtures of mud, ſand, clay, and the decayed parts of animals and vegetables; and more or leſs fertile, according to the abundance or want of theſe parts. To ſhew that this ſuppoſition on the formation of ſand and clay is not chimerical, I ſhall add ſome particular remarks.

I conceive, that the earth, in its firſt ſtate, was a globe, or rather a ſpheroid of compact glaſs, covered with a light cruſt of pumice ſtone and other ſcoria of the matter in fuſion. The motion and agitation of the waters and air ſoon reduced this cruſt into powder or ſand, which, by uniting afterwards, produced flints, and owe their hardneſs, colour, or tranſparency and variety, to the different degrees of purity of the ſand which entered into their compoſition.

Theſe ſands, whoſe conſtituting parts unite by fire, aſſimilate, and become very denſe, compact, and the more tranſparent as the ſand is more pure; on the contrary, being expoſed a long time to the air, they diſunite and exfoliate, deſcend in the form of earth, and it is probable the different clays are thus produced. This duſt, ſometimes of a brightiſh yellow, and ſometimes like ſilver, is nothing elſe but a very pure ſand ſomewhat periſhed, and almoſt reduced to an elementary ſtate. By time, particles will be ſo far attenuated and divided, that they will no longer have power to reflect the light, and acquire all the properties of clay.

This theory is conformable to what every day is ſeen; let us immediately waſh ſand upon its being dug, and the water will be loaded with a black ductile and fat earth, which is genuine clay. In ſtreets paved with free-ſtone, the dirt is always black and greaſy, and when dried appears to be an earth of the ſame nature as clay. Let us waſh the earth taken from a ſpot where there are neither free-ſtone nor flints, and there will always precipitate a great quantity of vitrifiable ſand.

But what perfectly proves that ſand, and even flint and glaſs, exiſt in clay, is, that the action of fire, by uniting the parts, reſtores it to its original form. Clay, if heated to the degree of calcination, will cover itſelf with a very hard enamel; if it is not vitrified internally, it nevertheleſs will have acquired a very great hardneſs, ſo as to reſiſt the file; it will emit fire under the hammer, and it has all the properties of flint; a greater degree of heat cauſes it to flow, and converts into real glaſs.

Clay and ſand are therefore matters perfectly analogous, and of the ſame claſs: if clay, by condenſing, may become flint and glaſs, why may not ſand, by diſſolution, become clay? Glaſs appears to be true elementary earth, and all mixed ſubſtances diſguiſed glaſs. Metals, minerals, ſalts, &c. are only vitrifiable earth; common ſtone and other matters analogous to it, and teſtaceous, and cruſtaceous ſhells, &c. are the only ſubſtances which cannot be vitrified, and which ſeem to form a ſeparate claſs. Fire, by uniting the divided parts of the firſt, forms an homogeneous matter, hard and tranſparent, without any diminution of weight, and to which it is not poſſible to cauſe any alteration; thoſe, on the contrary, in which a greater quantity of active and volatile principles enter, and which calcine, loſe more than one-third of their weight in the fire, and retake the form of ſimple earth, without any other alteration than a diſunion of their different parts: theſe bodies excepted, which are no great number, and whoſe combinations produce no great varieties in nature, every other ſubſtance, and particularly clay, may be converted into glaſs, and are conſequently only decompoſed glaſs. If the fire ſuddenly cauſes the form of theſe ſubſtances to change, by vitrifying them, glaſs itſelf, whether pure, or in the form of ſand or flint, naturally, but by a ſlow and inſenſible progreſs, changes into clay.

Where flint is the predominant ſtone, the country is generally ſtrewed with parts of it, and if the place is uncultivated, and theſe ſtones have been long expoſed to the air, without having been ſtirred, their upper ſuperficies is always white, whereas the oppoſite ſide, which touches the earth, is very brown, and preſerves its natural colour. If theſe flints are broken, we ſhall perceive that the whiteneſs is not only external, but penetrates internally, and there forms a kind of band, not very deep in ſome, but which in others occupies almoſt the whole flint. This white part is ſomewhat grainy, entirely opaque, as ſoft as free-ſtone, and adheres to the tongue like the boles, whereas the other part is ſmooth, has neither thread nor grain, and preſerves its natural colour, tranſparency and hardneſs. If this flint is put into a furnace, its white part becomes of a brick colour, and its brown part of a very fine white. Let us not ſay with one of our moſt celebrated naturaliſts, that theſe ſtones are imperfect flints of different ages, which have not acquired their perfection; for why ſhould they be all imperfect? Why ſhould they be imperfect only on the ſide expoſed to the weather? It, on the contrary, appears to me more reaſonable that they are flints changed from their original ſtate, gradually decompoſed, and aſſuming the form and property of clay or bole. If this is thought to be only conjecture, let the hardeſt and blackeſt flint be expoſed to the weather, in leſs than a year its ſurface will change colour; and if we have patience to purſue this experiment, we ſhall ſee it by degrees loſe its hardneſs, tranſparency and other ſpecific characters, and approach every day nearer and nearer the nature of clay.

What happens to flint happens to ſand; each grain of ſand may poſſibly be conſidered as a ſmall flint, and each flint as a maſs of extremely fine grains of ſand. The firſt example of the decompoſition of ſand is found in the brilliant opaque powder called Mica, in which clay and ſlate are always diffuſed. The entirely tranſparent flints, the Quartz, produce by decompoſition fat and ſoft talks, ſuch as thoſe of

Venice and Ruſſia, which are as ductile and vitrifiable as clay: and it appears to me, that talk is a mediate between glaſs or tranſparent flint and clay; whereas coarſe and impure flint, by decompoſing, paſſes to clay without any intermedium.

Our factitious glaſs undergoes the ſame alterations: it decompoſes and periſhes, as it were, in the air. At firſt it aſſumes a variety of colours, then exfoliates, and by working it we perceive brilliant ſcales fall off; but when its decompoſition is more advanced, it crumbles between the fingers, and is reduced into a very white fine talky powder. Art has even imitated nature in the decompoſition of glaſs and flint. "Eſt etiam certa methodus ſolius aquæ communis ope, ſilices & arenam in liquorem viſcoſum, eumdemque in ſal viride convertendi, & hoc in aleum rubicundum, &c. Solius ignis & aqua ope, ſpeciali experimento, duriſſimos quoſque lapides in mucorem reſolvo, qui diſtillan ſubtilem ſpiritum exhibet & oleum nullus laudibus prœdicabile *."

Theſe matters more particularly belong to metals, and when we come to them, ſhall be fully treated on, therefore we ſhall content ourſelves

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* See Becher. Phyſ. ſubter.

ourſelves here with adding, that the different ſtrata which cover the terreſtrial globe, being materials to be conſidered as actual vitrifications or analogous to glaſs, and poſſeſſing its moſt eſſential qualities; and as it is evident, that from the decompoſition of glaſs and flint, which is every day made before our eyes, a genuine clay remains, it is not a precarious ſuppoſition to advance, that clays and ſands have been formed by ſcoria, and vitrified drops of the terreſtrial globe, eſpecially when we join the proofs *à priori*, which we have given to evince the earth has been in a ſtate of liquefaction cauſed by fire.

ARTICLE VIII.

ON SHELLS, AND OTHER MARINE PRODUCTIONS FOUND IN THE INTERIOR PARTS OF THE EARTH.

I HAVE often examined quarries, the banks of which were filled with ſhells; I have ſeen entire hills compoſed of them, and chains of rocks which contained them throughout their whole extent. The quantity of theſe marine productions is aſtoniſhing, and the number in many places ſo prodigious, that it appears ſcarcely poſſible that any ſhould now remain in the ſea; it is by conſidering this innumerable multitude of ſhells, that no doubt is left of our earth having been a long time under the water of the ocean. The quantity found in a foſſil, or petrified ſtate, is beyond conception, and it is only from the number of thoſe that have been diſcovered that we could poſſibly have formed an idea of their multiplicity. We muſt imagine like thoſe who reaſon on matters they never ſaw, that ſhells are only found at random, diſperſed here and there, or in ſmall heaps, as oyſter ſhells thrown before our doors; on the contrary, they form mountains, are met with in ſhoals of 100 or 200 miles length, nay, they may ſometimes be traced through whole provinces in maſſes of 50 or 60 feet thick. It is from theſe circumſtances alone that we can reaſon on the ſubject.

We cannot give a more ſtriking example on this ſubject than the ſhells of Touraine. The following is the deſcription given of them by the hiſtorian of the Academy *.

" The

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* Anno 1720, page 5.

“ The number of figured ſtones and foſſil ſhells found in the bowels of the earth were remarked in all ages and nations, but they were conſidered merely as the ſports of nature, and even by philoſophers themſelves, as the productions of chance or accident, they regarded them with a degree of ſurpriſe, but paſſed them over with a ſlight attention, and all this phenomena periſhed without any fruit for the progreſs of knowledge. A potter in Paris, who knew neither Latin nor Greek, towards the end of the 16th century, was the firſt man who dared affirm, in oppoſition to the learned, that the foſſil ſhells were real ſhells formerly depoſited by the ſea in thoſe places where they were found; that animals, and particularly fiſh, had given to ſtones all theſe different figures, &c. and he defied the whole ſchool of Ariſtotle to contradict his proofs. This was Bernard Paliſſy, as great a natural genius as nature could form: his ſyſtem ſlept near 100 years, and even his name was almoſt forgot. At length the ideas of Paliſſy were revived in the mind of ſeveral philoſophers; and ſcience has profited by all the ſhells and figured ſtones the earth furniſhes us with; perhaps they are at preſent become only too common, and the conſequences drawn from them too inconteſtible.

"Notwithſtanding this, the obſervations preſented by M. Reaumur muſt appear wonderful. He diſcovered a maſs of 130 million, 680 thouſand cubical fathoms of ſhells, either whole or in fragments, without any mixture of ſtone, earth, ſand, or other extraneous matter: hitherto foſſil ſhells have never appeared in ſuch an enormous quantity, nor without mixture. It is in Touraine this prodigious maſs is found, more than 36 leagues from the ſea; this is perfectly known there, as the farmers of that province make uſe of theſe ſhells, which they dig up, as manure for their lands, to fertilize their plains, which otherwiſe would be abſolutely ſterile.

"What is dug from the earth, and which generally is no more than 8 or 9 feet deep, are only ſmall fragments of ſhells, very diſtinguiſhable as fragments, for they retain their original channels and hollows, having only loſt their gloſs and colour, as almoſt all ſhells do which we find in the earth. The ſmalleſt pieces, which are only duſt, are ſtill diſtinguiſhable, becauſe they are perfectly of the ſame matter as the reſt, as well as of the whole ſhells which are ſometimes found. We diſçover the ſpecies as well in the whole ſhells as in the larger fragments. Some of theſe ſpecies are known at Poitou, others belong to more remote coaſts. There are even fragments of madrepores, coral, and other productions of the ſea; all this matter in the country is termed *Fallum*, and is found wherever the ground is dug in that province for the ſpace of nine leagues ſquare. The peaſants do not dig above twenty feet deep, becauſe they think it would not repay them for their trouble, but they are certainly deeper. The calculation of the quantity is however taken upon the ſuppoſition of only 18 feet and 2200 fathoms to the league. This maſs of ſhells of courſe exceeds the calculation, and poſſibly contains double the quantity.

" In phyſical points the ſmalleſt circumſtances, which moſt people do not think worthy of remarking, ſometimes lead to conſequences and afford great lights. M. de Reaumur obſerved, that all theſe fragments of ſhells lie horizontally, and hence he has concluded that this infinity of fragments does not proceed from the heap being formed at one time, or of whole ſhells, for the uppermoſt, by their weight, would have cruſhed the others, and of courſe their fallings would have given an infinity of different poſitions. They muſt, therefore, have been brought there by the ſea, either whole or broken, and neceſſarily placed horizontally; and although the extreme length of time was of itſelf ſufficient to break, and almoſt calcine the greateſt part, it could not change their poſition.

" By this it appears, that they muſt have been brought gradually, and in fact how was it poſſible that the ſea could convey at once ſuch an immenſe quantity of ſhells, and at the ſame time preſerve a poſition perfectly horizontal? they muſt have collected in one ſpot, and conſequently this ſpot muſt have been the bottom of a gulph or baſon.

" All this proves, that although there muſt remain on the earth many veſtiges of the univerſal deluge, as recorded in ſcripture, the maſs of ſhells at Touraine was not produced by that deluge; there is perhaps not ſo great a maſs in any part of the ſea; but even had the deluge forced them away, it would have been with an impetuoſity and violence that would not have permitted them to retain one uniform poſition. They muſt have been brought and depoſited gently and ſlowly, and conſequently their accumulation required a ſpace of time much longer than a year.

The ſurface of the earth, it is evident, muſt have been before or after the deluge very differently diſpoſed to what it is at preſent, that the ſea and continent had another arrangement, and formerly there was a great gulph in the middle of Touraine. The changes which are known from hiſtory, or even ancient fable, are inconſiderable, but they give us room to imagine thoſe which a longer time might bring about. M. de Reaumur ſuppoſes that Touraine was a gulph of the ſea which communicated with the ocean, and that the ſhells were carried there by a current; but this is a ſimple conjecture laid down in room of the real unknown fact. To ſpeak with certainty on this matter, we ſhould have geographical maps of all the places where ſhells have been dug from the earth, to obtain which would require almoſt an infinity of time and obſervation, yet it is poſſible that hereafter ſcience may accompliſh it.

This quantity of ſhells, conſiderable as it is, will aſtoniſh us leſs if we conſider the following circumſtances: firſt, ſhell fiſh multiply prodigiouſly, and are full grown in a very ſhort time; the abundance of individuals in each kind proves to us their fertility. We have a ſtrong example of this increaſe in oyſters, a maſs of many fathoms of which are frequently raiſed in a ſingle day. In a very ſhort time the rocks to which they are attached are conſiderably diminiſhed, and ſome banks quite exhauſted, nevertheleſs the enſuing year we find them as plentiful as before, nor do they appear to be in the leaſt diminiſhed; indeed I know not whether a natural bed of oyſters was ever entirely exhauſted. Secondly, the ſubſtance of ſhells is analogous to ſtone; they are a long time preſerved in ſoft matters, and petrify readily in hard; theſe ſhells and marine productions therefore found on the earth, being the wrecks of many ages, muſt of courſe have formed very conſiderable maſſes.

There are a prodigious quantity of ſhells in marble, lime, ſtone, chalk, marl, &c. we find them, as before obſerved, in hills and mountains, and they often make more than one half of the bodies which contain them; for the moſt part they appear well preſerved, others are in fragments, but large enough to diſtinguiſh to what kind of ſhells they belong. Here our knowledge on this ſubject, from obſervation, finds its limits; but I ſhall go further and aſſert that ſhells are the intermedium which Nature adopts for the formation of moſt kind of ſtones; that chalks, marls, and lime-ſtone are compoſed only of the powder and pieces of ſhells; that conſequently the quantities of ſhells deſtroyed are infinitely more conſiderable than thoſe preſerved. I ſhall here content myſelf with indicating the point of view in which we ought to conſider the ſtrata of which the globe is compoſed. The firſt ſtratum is compoſed of the duſt of the air, the ſediment of the rain, dew, and vegetable or animal parts, reduced to particles; the ſtrata of chalk, marl, lime, ſtone, and marble, are compoſed of the ruins of ſhells, and other marine productions, mixed with fragments or whole ſhells; but the vitriſiable ſand or clay are the matters of which the internal parts of the globe are compoſed. They were vitrified when the globe received its form, which neceſſarily ſuppoſes that the matter was in fuſion. The granate, rock, flint, &c. owe their origin to ſand and clay, and are likewiſe diſpoſed by ſtrata; but tuffa *, free-ſtone, and flints (not in great maſſes), cryſtals, metals, pyrites, moſt minerals, ſulphurs, &c. are

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* A kind of ſoft gravelly ſtone.

are matters whoſe formation is novel, in compariſon with marbles, calcinable ſtones, chalk, marl, and all other materials diſpoſed in horizontal ſtrata, and which contain ſhells and other productions of the ſea.

As the denominations I make uſe of may appear obſcure or equivocal, it is neceſſary to explain them. By the term *clay*, I mean not only the white and yellow, but alſo blue, ſoft, hard, foliated, and other clays, which I look on as the ſcoria of glaſs, or as decompoſed glaſs. By the word *ſand* I always underſtand vitrifiable ſand; and not only comprehend under this denomination the fine ſand which produces free-ſtone, and which I look upon as powdered glaſs, or rather pumice ſtone, but alſo the ſand which proceeds from the free-ſtone deſtroyed by friction, and alſo the larger ſand, as ſmall gravel, which proceeds from the granate and rock-ſtone, and is ſharp, angular, red, and commonly found in the bed of rivers or rivulets that derive their waters immediately from the higher mountains, or hills compoſed of ſtone or granate. The river Armanſon conveys a great quantity of this ſand; it is large and brittle, and in fact is only fragments of rock ſtone, as calcinable gravel is of free-ſtone. *Rock-*

ſtone and *granate* are one and the ſame ſubſtance, but I have uſed both denominations, becauſe there are many perſons who make two different ſpecies of them. It is the ſame with reſpect to flints and free-ſtone in large pieces; I look on them as kinds of granate, and I call them *large flints*, becauſe they are diſpoſed like calcinable ſtone in ſtrata, and to diſtinguiſh them from the flints and free-ſtone in ſmall maſſes, and the round flints which have no regular quarries, and whoſe beds have a certain extent; theſe are of a modern formation, and have not the ſame origin as the flints and free-ſtone in large lumps, which are diſpoſed in regular ſtrata.

I underſtand by the term *ſlate*, not only the blue, which all the world knows, but white, grey, and red ſlate: theſe bodies are generally met with below laminated clay, and have every appearance of being nothing more than clay hardened in this ſtrata. Pit coal and jet are matters which alſo belong to clay, and are commonly under ſlate. By the word *tuffa*, I underſtood not only the common pumice which appears full of holes, and, as I may ſay, organized, but all the beds of ſtone made by the ſediment of running waters, all the ſtalactites, incruſtations, and all kinds of ſtone that diſſolve by fire. It is no ways doubtful that theſe matters are not modern, and that they every day grow. Tuffa is only a maſs of lapidific matter in which we perceive no diſtinct ſtrata: this matter is diſpoſed generally in ſmall hollow cylinders, irregularly grouped and formed by waters dropt at the foot of mountains, or on the ſlope of hills, which contain beds of marl or ſoft and calcareous earth; theſe cylinders, which make one of the ſpecific characters of this kind of tuffa, is either oblique or vertical according to the direction of the ſtreams or water which form them. Theſe ſort of ſpurious quarries have no continuation; their extent is very confined, and proportionate to the height of the mountains which furniſh them with the matter of their growth. The tuffa every day receiving lapidific juices, thoſe ſmall cylindrical columns, between which intervals are left, cloſe at laſt, and the whole becomes one compact body, but never acquires the hardneſs of ſtone, and is what Agricola terms *Marga toſocea fiſtuloſa.* In this tuffa are generally found impreſſions of leaves, trees, and plants, like thoſe which grow in the environs: terreſtrial ſhells alſo are often met with, but never any of the marine kind. The tuffa is certainly therefore a new matter, which muſt be ranked with ſtalactites, incruſtations, &c. all theſe new matters are kinds of ſpurious ſtones, formed at the expence of the reſt, but which never arrive at true petrification.

Cryſtal, precious ſtones, and all thoſe which have a regular figure, even ſmall flints formed by concentrical beds, whether found in perpendicular cavities of rocks, or elſewhere, are only exudations of large flints, or concrete juices of the like matters, and are therefore ſpurious ſtones, and real ſtalactites of flint or rock.

Shells are never found either in rock, granate, or free-ſtone, although they are often met with in vitrifiable ſand, from which theſe matters derive their origin; this ſeems to prove that ſand cannot unite to form free-ſtone or rock but when it is pure, and that if it is mixed with ſhells or ſubſtances of other kinds, which are heterogeneous to it, its union is prevented. I have obſerved the little pebbles which are often found in beds of ſand mixed with ſhells, but never found any ſhell therein: theſe pebbles are real concretions of free-ſtone formed in the ſand in the places where it is not mixed with heterogeneous matters which oppoſe the formation of larger maſſes.

We have before obſerved, that at Amſterdam, which is a very low country, ſea ſhells were found at 100 feet below the earth, and at Marly-la-Ville, ſix miles from Paris, at 75 feet; we likewiſe meet with the ſame at the bottom of mines, and in banks of rocks, beneath a height of ſtone 50, 100, 200, and 1000 feet thick, as is apparent in the Alps and Pyrennees, where, in the lower beds, ſhells and other marine productions are conſtantly found. But to proceed in order, we find ſhells on the mountains of Spain, France, and England; in all the marble quarries of Flanders, in the mountains of Guelders, in all hills around Paris, Burgundy, and Champagne; in one word, in every place where the baſis of the ſoil is not free-ſtone or tuffa; and in moſt of theſe places there are more ſhells than other matters in the ſubſtance of the ſtones. By *ſhells*, I mean not only the wrecks of ſhell fiſh, but thoſe of cruſtaceous animals, the briſtles of ſea hedge-hogs, and all productions of the ſea inſects, as coral, madrepores, aſtroites, &c. We may eaſily be convinced by inſpection, that in moſt calcinable ſtones and marble, there is ſo great a quantity of theſe marine productions that they appear to ſurpaſs the matter which unites them.

But let us proceed; we meet with theſe marine productions even on the tops of the higheſt mountains; for example, on Mount Cenis, in the mountains of Genes, in the Apennines, and in moſt of the ſtone and marble quarries in Italy; alſo in the ſtones of the moſt ancient edifices of the Romans; in the mountains of Tirol; in the centre of Italy, on the ſummits of Mount Paterne, near Bologna; in the hills of Calabria; in many parts of Germany and Hungary, and generally in all the high parts of Europe *.

In Aſia and Africa, travellers have remarked them in ſeveral parts; for example, on the mountains of Caſtravan, above Barut, there is a bed of white ſtone as thin as ſlate, each leaf of which contains a great number and diverſity of fiſhes; they lie for the moſt part very flat and compreſſed, as does the foſſil fern-plants, but they are notwithſtanding ſo well preſerved, that the ſmalleſt traces of the fins, ſcales, and all the parts which diſtinguiſh each kind of fiſh, are perfectly viſible. So likewiſe we find many ſea

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* On this ſubject ſee Stenon, Ray, Woodward, and others.

ſea muſcles, and petrified ſhells between Suez and Cairo, and on all the hills and eminences of Barbary ; the greateſt part are conformable to the kinds at preſent caught in the Red ſea *. In Europe, we meet with petrified fiſh in Sweden and Germany, and in the quarry of Oningen, &c.

The long chain of mountains, ſays Bourguet, which extends from Portugal to the moſt eaſtern parts of China, the mountains of Africa and America, and the vallies of Europe, all incloſe ſtones filled with ſhell-fiſh, and from hence, he ſays, we may conclude the ſame of all the other parts of the world unknown to us.

The iſlands in Europe, Aſia, and America, where men have had occaſion to dig, whether in mountains or plains, furniſh examples of foſſil ſhells, which evince that they have that in common with the bordering continents.

Here then is ſufficient facts to prove that ſea ſhells, petrified fiſh, and other marine productions are to be found in almoſt every place we are diſpoſed to ſeek them.

" It is certain, ſays an Engliſh author (Tancred Robinſon), that there have been ſea-ſhells diſperſed on the earth by armies, and the inhabitants

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* See Shaw's Voyages, Vol. II, page 40 and 41.

inhabitants of towns and villages, and that Loubere relates in his Voyage to Siam, that the monkies of the Cape of Good Hope continually amuſe themſelves with carrying ſhells from the ſea ſhores to the tops of the mountains; but that cannot reſolve the queſtion, why theſe ſhells are diſperſed over all the earth, and even in the interior parts of mountains, where they are depoſited in beds like thoſe in the bottom of the ſea."

On reading an Italian letter on the changes happened to the terreſtrial globe, printed at Paris in the year 1746, I was ſurpriſed to find theſe ſentiments of Loubere exactly correſponded. Petrified fiſh, according to this writer, are only fiſh rejected from the Roman tables, becauſe they were not eſteemed wholeſome; and with reſpect to foſſil-ſhells, he ſays the pilgrims of Syria brought, during the times of the Cruſades, thoſe of the Levant Sea, into France, Italy, and other Chriſtian ſtates; why has he not added that it was the monkies who tranſported the ſhells to the tops of theſe mountains, which were never inhabited by men? this would not have ſpoiled but rendered his explanation ſtill more probable.

How comes it that enlightened perſons, who pique themſelves on philoſophy, have ſuch various ideas on this ſubject? But doing ſo, we ſhall not content ourſelves with having ſaid that petrified ſhells are found in almoſt every part of the earth which has been dug, nor with having related the teſtimonies of authors of natural hiſtory; as it might be ſuſpected, that with a view of ſome ſyſtem, they perceived ſhells where there were none; but quote the authority of ſome authors, who merely remarked them accidentally, and whoſe obſervations went no farther than recogniſing thoſe that were whole and in the beſt preſervation. Their teſtimony will perhaps be of a ſtill greater authority with people who have it not in their power to be aſſured of the truth of theſe facts, and who know not the difference between ſhells and petrifications.

All the world may ſee the banks of ſhells in the hills in the environs of Paris, eſpecially in the quarries of ſtone, as at Chauſſée, near Séve, at Iſſy, Paſſy, and elſewhere. We find a great quantity of lenticular ſtones at Villers-Cotterets; theſe rocks are entirely formed thereof, and they are blended without any order with a kind of ſtony mortar, which binds them together.

ther. At Chaumont ſo great a quantity of petrified ſhells are found that the hills appear to be compoſed of nothing elſe. It is the ſame at Courtagnon, near Rheims, where there is a bank of ſhells near four leagues broad, and whoſe length is conſiderably more. I mention theſe places as being famous and ſtriking the eye of every beholder.

With reſpect to foreign countries, here follows the obſervations of ſome travellers :

" In Syria and Phœnicia, the rocks, particularly in the neighbourhood of Latikea, are a kind of chalky ſubſtance, and it is perhaps from thence that the city has taken the name of the white promontory. Nakoura, anciently termed Scala Tyriorum, or the Tyrians Ladder, is nearly of the ſame nature, and we ſtill find there, by digging, quantities of all ſorts of ſhells, corals, and other remains of the deluge *."

" On mount Sinia, we find only a few foſſil ſhells, and other marks of the deluge, at leaſt if we do not rank the foſſil Tarmarin of the neighbouring mountains of Siam among this number, perhaps the firſt matter of which their marble

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* See Shaw's Travels.

marble is formed, had a corroſive virtue not proper to preſerve them. But at Corondel, where the rocks approach nearer our free-ſtone, I found many ſhells, as alſo a very ſingular ſea muſcle, of the deſcoid kind, but cloſer and rounder. The ruins of the little village Ain le Mouſa, and many canals which conduct the water thereto, furniſh numbers of foſſil ſhells. The ancient walls of Suez, and what yet remains of its harbour, have been conſtructed of the ſame materials, which ſeem to have been taken from the ſame quarry. Between, as well as on all the mountains, eminences and hills of Lybia, near Egypt, we meet with a great quantity of ſea weed, as well as vivalvous ſhells, and of thoſe which terminate in a point, moſt of which are exactly conformable to the kinds at preſent caught in the Red Sea.

The moving ſand in the neighbourhood of Ras Sem, in the kingdom of Barca, covers many palm trees with petrifications. Ras Sem ſignifies the head of a fiſh, and is what we term the petrified village, where it is ſaid men, women, and children are found, who with their cattle, furniture, &c. have been converted into ſtone; but theſe, ſays Shaw, are vain tales and fables, as I have not only learnt from M. le

Maire, who at the time he was Conſul at Tripoly, ſent ſeveral perſons thither to take cognizance of it, but alſo from very reſpectable perſons who had been at thoſe places.

Near the pyramids certain pieces of ſtone worked by the ſculptor were found by Mr. Shaw, and among theſe ſtones many rude ones of the figure and ſize of lentils; ſome even reſemble barley half-peeled; theſe, he ſays, were reported to be the remains of what the workmen ate, but which does not appear probable, &c. Theſe lentils and barley are nothing but petrified ſhells called by naturaliſts lentil-ſtones.

According to Miſſon, ſeveral ſorts of theſe ſhell-fiſh are found in the environs of Maeſtricht, eſpecially towards the village of Zicken, or Tichen, and at the little mountain called Huns. In the environs of Sienna, near Ceraldo, are many mountains of ſand crammed with divers ſorts of ſhells. Montemario, a mile from Rome, is entirely filled with them; I have ſeen them in the Alps, France, and elſewhere. Olearius, Steno, Cambden, Speed, and a number of other authors, as well ancient as modern, relate the ſame phenomena.

" The iſland of Cerigo, ſays Thevenot, was anciently called Porphyris, from the quantity of Porphyry which was taken out of it *.

" Oppoſite the village of Inchene, and on the eaſtern ſhore of the Nile, I found petrified plants, which grow naturally in a ſpace about two leagues long, by a very moderate breadth; this is one of the moſt ſingular productions of nature. Theſe plants reſemble the white coral found in the Red Sea †."

" There are petrifications of divers kinds on Mount Libanus, and among others flat ſtones, where the ſkeletons of fiſh are found well preſerved and entire; red cheſnuts and ſmall branches of coral, the ſame as grow in the Red Sea, are alſo found on this mountain."

" On Mount Carmel we find a great quantity of hollow ſtones, which have ſomething of the figure of melons, peaches, and other fruits, which are ſaid to be ſo petrified: they are commonly ſold to pilgrims, not only as mere curioſities, but alſo as remedies againſt many diſorders. The olives which are the *lapides jadaici*, are to be met with at the druggiſts, and have always been looked upon, when diſſolved in the juice of lemon, as a ſpecific for the ſtone and gravel."

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* Thevenot, Vol. 1, page 25.

† Voyage of Paul Lucus, Vol. 11, page 380.

"M. la Roche, a phyſician, gave me ſome of theſe petrified olives, which grew in great plenty in theſe mountains, where I am told are found other ſtones, the inſides of which perfectly reſemble the natural parts of men and women. Theſe are Hyſterolithes."

"In going from Smyrna to Tauris, when we were at Tocat, ſays Tavernier, the heat was ſo great, as obliged us to quit the common road, and go by the mountains, where there is conſtantly ſhade and refreſhing air. In many places we found ſnow and a quantity of very fine ſorrel, and on the top of ſome of thoſe mountains we found ſhells like thoſe upon the ſea ſhores, which was very extraordinary."

Here follows what Olearius ſays on the ſubject of petrified ſhells, which he remarked in Perſia, and in the rocks where the ſepulchres are cut out near to the village of Pyrmaraus:

"We were three in company that aſcended to the top of the rock by the moſt frightful precipices, mutually aſſiſting each other: having gained the ſummit, we found four large chambers, and within many niches cut in the rocks to ſerve for beds: but what the moſt ſurpriſed us was to find in this vault, on the top of the mountain, muſcle ſhells; and in ſome places they were in ſuch great quantities, that the whole rock appeared to be compoſed only of ſand and ſhells. Returning to Perſia, we perceived many of theſe ſhelly mountains along the coaſt of the Caſpian Sea."

To theſe I could ſubjoin many other authorities which I ſuppreſs, not willing to tire thoſe who have no need of ſuperabundant proofs, and who are convinced by their ſight, as I have been, of the exiſtence of ſhells wherever we chuſe to ſeek for them.

In France, we not only find the ſhells of the French coaſt, but alſo ſuch as have never been ſeen in thoſe ſeas. Some philoſophers aſſert, that the quantity of theſe foreign petrified ſhells is much greater than thoſe of our climate; but I think this opinion unfounded; for, independent of the ſhell-fiſh which inhabit the bottom of the ſea, and are ſeldom brought up by the fiſhermen, and which conſequently may be looked on as foreigners, although they exiſt in our ſeas, I ſee, by comparing the petrifactions with the living analagous animals, there are more of thoſe of our coaſts than of others: for example, moſt of the cockles, muſcles, oyſters, ear-ſhells, limpets, nautili, ſtars, tubulites, corals, madrepores, &c. found in ſo many places, are certainly the productions of our ſeas; and though a great number appear which are foreign or unknown, the cornu ammonis, the lapides juduica, &c. yet I am convinced, from repeated obſervations, that the number of theſe kinds is ſmall in compariſon with the ſhells of our own coaſts: beſides, what compoſes the bottom of almoſt all our marble and lime-ſtone but madrepores, aſtroites, and all thoſe other productions which are formed by ſea inſects, and formerly called marine plants? Shells, however abundant, form only a ſmall part of theſe productions, many of which originate in our ſeas, and particularly in the Mediterranean.

The Red Sea produces corals, madrepores, and marine plants in the greateſt abundance; no part furniſhes a greater variety than the port of Tor; in calm weather, ſo great a quantity preſent themſelves, that the bottom of the ſea reſembles a foreſt; ſome of the branched madrepores are eight or ten feet high. In the Mediterranean Sea, at Marſeilles, near the coaſts of Italy and Sicily. In moſt of the gulphs of the ocean, around iſlands, on banks, and in all temperate climates, where the ſea is but of a moderate depth, they are very common.

M. Peyſſonel was the firſt who diſcovered that corals, madrepores, &c. owed their origin to animals, and were not plants as had been ſuppoſed. The obſervation of M. Peyſſonel was a long time doubted: ſome naturaliſts at firſt rejected it with a kind of diſdain; nevertheleſs they have been obliged ſince to acknowledge its truth, and the whole world is at length ſatisfied that theſe, formerly ſuppoſed marine plants, are nothing but hives or cells formed by inſects, in which they live as fiſh do in their ſhells. Theſe bodies were at firſt placed in the claſs of minerals, then paſſed into that of vegetables and now remain fixed in that of animals, the genuine operations of which they muſt ever be conſidered.

There are ſhell-fiſh which live at the bottom of the ſea, and which are never caſt on the ſhore: authors call them Pelogiæ, to diſtinguiſh them from the others which they call Litterales. It is to be ſuppoſed the cornu ammonis, and ſome other kinds that are only found in a petrified ſtate, belong to the former, and that they were filled with the ſtony ſediment in the very places they are found. There might alſo have been certain animals, whoſe ſpecies are periſhed, and of which number this ſhell-fiſh might be ranked. The extraordinary foſſil bones found in Siberia, Canada, Ireland, and many other places, ſeem to confirm this conjecture ; for no animal has hitherto been diſcovered to whom ſuch bones could belong, as they are, for the moſt part, of an enormous ſize.

Theſe ſhells, according to Woodward, are met with from the top to the bottom of quarries, pits, and at the bottom of the deepeſt mines of Hungary. And Mr. Ray aſſures us, they are found a thouſand feet deep in the rocks which border the iſle of Calda, and in Pembrokeſhire in England.

Shells are not only found in a petrified ſtate at great depths, and at the tops of the higheſt mountains; but there are ſome met with in their natural condition, and which have the gloſs, colours, and lightneſs of ſea-ſhells : and to convince ourſelves entirely of this matter, we have only to compare them with thoſe found on the ſea ſhores. A ſlight examination will prove that theſe foſſil and petrified ſhells are the ſame as thoſe of the ſea; they are marked with the ſame articulations; and in the gloſſopetri, and other teeth of fiſhes, which are ſometimes found adhering to the jaw-bone, the teeth of the fiſh are remarked to be ſmooth, and worn at the extremities, and that they have been made uſe of when the animals were alive.

Almoſt every where on land we meet with foſſil-ſhells, and of thoſe of the ſame kind, ſome are ſmall, others large, ſome young, others old; ſome imperfect, others extremely perfect; and we likewiſe ſometimes ſee the young ones adhering to the old.

The ſhell-fiſh called *purpura* has a long tongue, the extremity of which is bony, and ſo ſharp, that it pierces the ſhells of other fiſh; by which means it draws nutriment from them. Shells pierced in this manner are frequently found in the earth, which is an inconteſtible proof that they formerly encloſed living fiſh, and exiſted in thoſe parts where there were the Purpura.

The obeliſks of St. Peter's, at Rome, according to John of Latran, were ſaid to come from the pyramids of Egypt: they are of red granate, which is a kind of rock-ſtone, and as we have obſerved, contains no ſhells; but the African and Egyptian marble, and the porphyry ſaid to have been cut from the temple of Solomon, and the palaces of the kings of Egypt, and uſed at Rome in different buildings, are filled with ſhells. Red porphyry is compoſed of an infinite number of prickles of the ſpecies of echinus, or ſea cheſnut; they are placed pretty near each other, and form all the ſmall white ſpots which are in the porphyry. Each of theſe white ſpots has a black one in its centre, which is the ſection of the longitudinal tube of the prickles of the echinus. At Fichen, three leagues from Dijon, in Burgundy, is a red ſtone perfectly ſimilar in its compoſition to porphyry, and which differs from it only in hardneſs, not being more ſo than marble; it appears almoſt formed of prickles of the echini, and its beds are of a very great extent. Many beautiful pieces of workmanſhip have been made of it in this province, and particularly the ſteps of the pedeſtal of the equeſtrian ſtatue of Louis le Grand, at Dijon.

This ſpecies of ſtone is alſo found at Montbard, in Burgundy, where there is an extenſive quarry; it is not ſo hard as marble, contains more of the echini, and leſs of the red matter.

From this it appears that the ancient porphyry of Egypt differs only from that of Burgundy in the degree of hardneſs, and the number of the points of the echini.

With reſpect to what the curious call green porphyry, I rather ſuppoſe it to be a granate than a porphyry; it is not compoſed of ſpots like the red porphyry, and its ſubſtance appears to be ſimilar to that of a common granate. In Tuſcany, in the ſtone with which the ancient walls of Volatera were built, there are a great quantity of ſhells, and this wall was built 2500 years ago. Moſt marbles, porphyries, and other ſtones of the moſt ancient buildings, contain ſhells and other wrecks of marine productions, as well as the marble we at preſent take from the quarry; therefore it cannot be doubted, independent even of the ſacred teſtimony of holy writ, that before the deluge the earth was compoſed of the ſame materials as it is at preſent.

From all theſe facts it is plain that petrified ſhells are found in Europe, Aſia, Africa, and in every place where the obſervations have been made; they are alſo found in America, in the Braſils: for example, in Tucumama, in Terra Magellinica, and in ſuch a great quantity in the

Antilles, that directly below the cultivable land, the bottom of which the inhabitants call lime, is nothing but a compoſition of ſhells, madrepores, aſtroites, and other productions of the ſea. Theſe facts would have made me think that ſhells and other petrified marine productions, were to be found in the greateſt part of the continent of America, and eſpecially in the mountains, as Woodward aſſerts; but M. Condamine, who lived ſeveral years at Peru, has aſſured me he could not diſcover any in the Cordeliers, although he had carefully ſought for them. This exception would be ſingular, and the conſequences that might be drawn from it would be ſtill more ſo; but I own, that in ſpite of the teſtimony of this celebrated naturaliſt, I am much inclined to ſuppoſe, that in the mountains of Peru, as well as elſewhere, there are ſhells and other marine petrifications, although they have not been diſcovered. It is well known, that in matter of teſtimonies, two poſitive witneſſes, who aſſert to have ſeen a thing, is ſufficient to make a complete proof; whereas ten thouſand negative witneſſes, and who can only aſſert not to have ſeen a thing, can only raiſe a ſlight doubt. This reaſon, united with the ſtrength of analogy, induces me to perſiſt in thinking the ſhells will be found on the mountains of Peru, eſpecially if we ſearch for them on the riſe of the mountain, and not at the ſummit.

The tops of the higheſt mountains are generally compoſed of rock, ſtone granate, and other vitrifiable matters, which contain no ſhells.

All theſe matters were formed out of the beds of the ſand of the ſea, which covered the tops of theſe mountains. When the ſea left them, the ſand and other light bodies were carried by the waters into the plains, ſo that there remained only rocks on the tops of the mountains, which had been formed under thoſe beds of ſand. At two, three, or four hundred fathoms below the tops of theſe mountains, are often found marble and other calcinable matter, which are diſpoſed in parallel ſtrata, and contain ſhells and other marine productions; therefore it is not ſurpriſing that M. de la Condamine did not find any ſhells on theſe mountains, eſpecially if he ſought for them in the elevated parts of thoſe mountains which are compoſed of rock, free-ſtone, or vitrifiable ſand; but had he examined the lower parts of the Cordeliers, he would undoubtedly have found ſtrata of ſtone, marble, earth, &c. mixed with ſhells; for in every country where obſervations have been made, ſuch beds have always been met with.

But ſuppoſe that in fact there are no marine productions in the mountains of Peru, all that may be concluded from it will no ways affect our theory; and it might be poſſible, that there are ſome parts of the globe which never were covered with water, eſpecially of ſuch elevation as the Cordeliers. But in this caſe there might be ſome curious obſervations made on thoſe mountains, for they would not be compoſed of parallel ſtrata, the materials alſo would be very different from thoſe we are acquainted with; they would not have perpendicular cracks; the compoſition of the rocks and ſtones would not at all reſemble thoſe of other countries; and laſtly, in theſe mountains we ſhould find the ancient ſtructure of the earth, ſuch as it originally was before it was changed by the motion of the waters; we ſhould ſee the firſt ſtate of the globe, the old matters of which it was compoſed, its form, and the natural arrangement of its parts, but this is too much to expect, and on too ſlight foundations; and it is more conformable to reaſon to conclude that foſſil-ſhells are to be found in thoſe mountains, as well as in every other place.

With reſpect to the manner in which ſhells are placed in the ſtrata of earth or ſand, Woodward ſays, " All ſhells that are met with in an infinity of ſtrata of earth, and banks of rocks, in the higheſt mountains, and in the deepeſt quarries and mines, in flints, &c. &c. in maſſes of ſulphur, marcaſites, and other metallic and mineral bodies, are filled with ſimilar ſubſtances to that which includes them, and never any heterogenous matter, &c.

" In the ſand ſtones of all countries (the ſpecific weight of the different kinds of which vary but little, being generally with reſpect to water as $2\frac{1}{2}$ or $\frac{9}{16}$ to 1), we find only the conchae, and other ſhells which are nearly of the ſame weight, but they are uſually found in very great numbers, whereas it is very rare to meet with oyſter-ſhells (whoſe ſpecific weight is but as $2\frac{1}{3}$ to 1), or ſea cockles (whoſe weight is but as 2 or $2\frac{1}{8}$ to 1), or other ſorts of lighter ſhells; but on the contrary in chalk, (which is lighter than ſtone, being to water but as $2\frac{1}{10}$ to 1), we find only cockles and other kinds of lighter ſhells, page 32, 33."

It muſt be remarked, that what Woodward ſays in this place with reſpect to ſpecific gravity, muſt not be looked upon as a general rule, for we find lighter and heavier ſhells in the ſame matters; for example, ſhells of cockles, of oyſters, of echini, &c. are found in the ſame ſtones and earth; and even in the royal cabinet may be ſeen a petrified cockle in a cornelian, and echini petrified in an agate, &c. therefore the ſpecific weight of the ſhells has not influenced ſo much as Woodward ſuppoſes their poſition in the earth. The reaſon why ſuch light ſhells are found more abundantly in chalk is, that chalk is only the ruinated part of ſhells, and that thoſe of the echini being lighter and thinner than others, would have been moſt eaſily reduced into powder or chalk, ſo that the ſtrata of chalk are only met with in the places where formerly a great abundance of theſe light ſhells were collected, the deſtruction of which formed that chalk, in which we find thoſe ſhells, which having reſiſted the frictions, are preſerved entire, or at leaſt in parts large enough to diſcover their ſpecies.

But this ſubject is treated more fully in our diſcourſe on minerals; we ſhall here content ourſelves with ſaying, that a modification muſt be given to Woodward's expreſſions: he ſeems to ſay, that ſhells are found in flints, cornelians, in ores, and ſulphur, as often, and in as great a number as in other matters; whereas the truth is, that they are very rare in all vitrifiable or purely inflammable ſubſtances; and, on the contray, are in prodigious abundance in chalk, marl, and marbles, inſomuch that we cannot abſolutely pretend to ſay, that the lighteſt and heavieſt ſhells are found in correſponding ſtrata, but only that in general they are oftener found ſo than otherwiſe. They are all filled with the ſubſtance which ſurrounds them, whether found in horizontal ſtrata, or in perpendicular fiſſures, becauſe both have been formed by the waters, although at different times and in different manners. Thoſe found in horizontal ſtrata of ſtone, marble, &c. have been depoſited by the motion of the waves of the ſea, and thoſe in flints, cornelians, and all matters which are in the perpendicular fiſſures have been produced by the particular motion of a ſmall quantity of water, loaded with lapidific or metallic ſubſtances. In both caſes theſe matters were reduced into a fine and impalpable powder, which has filled the ſhells ſo fully and abſolutely, as not to have left the leaſt vacuum.

There is therefore in ſtone, marble, &c. a great multitude of ſhells which are whole, beautiful, and ſo little changed, that they may be eaſily compared with the ſhells preſerved in cabinets, or found on the ſea ſhores.

Woodward, in pages 23 and 24, proceeds, "There are, beſides theſe, great multitudes of ſhells contained in ſtones, &c. which are entire and abſolutely free from any ſuch mineral mixture; which may be compared with thoſe at this time ſeen on our ſhores, and which will be found not to have any difference, being preciſely of the ſame figure and ſize; of the ſame ſubſtance and texture as the peculiar matter which compoſes them is the ſame, and is diſpoſed and arranged in the ſame manner; the direction of their fibres and ſpiral lines are the ſame, the compoſition of the ſmall lama formed by their fibres is the ſame in the one as the other; we ſee in the ſame part veſtigia of tendons, by means of which the animal was faſtened and joined to its ſhell; we ſee the ſame tubercles, ſtria and pipes; in ſhort the whole is alike, whether within or without the ſhell, in its cavity or on its convexity, in its ſubſtance or on its ſuperficies. In other reſpects theſe foſſil ſhell-fiſh are ſubject to the ſame common accidents as thoſe of the ſea; for example, they ſometimes grow to one another, the leaſt are adherent to the large; they have vermicular conduits; pearls are found therein, and other ſimilar matters which have been produced by the animal when it inhabited its ſhell, and what is very conſiderable, their ſpecific gravity is exactly the ſame as that of their kind found actually in the ſea; in all chymical experiments they anſwer exactly with ſea-ſhells; when diſſolved they have the ſame appearance, ſmell and taſte; in a word, their reſemblance is perfectly exact.

I have often obſerved with aſtoniſhment, as I have already ſaid, whole mountains, chains of rocks, enormous banks of quarries, ſo full of ſhells and other wrecks of marine productions, that their bulk ſurpaſſed that of the matter in which they were depoſited.

I have ſeen cultivated fields ſo full of petrified cockles that a man might pick them up with his eyes ſhut, others covered with cornu ammonis, and ſome with cardites, and the more we examine the earth, the more we ſhall be convinced that the number of theſe petrifications is infinite, and conclude, that it is impoſſible that all the animals which inhabited theſe ſhells exiſted at one time.

I have made an obſervation, that in all countries where we find a very great number of petrified ſhells in the cultivated lands which are whole, well preſerved and totally apart, have been divided by the action of the froſt, which deſtroys the ſtone and ſuffers the petrified ſhells to ſubſiſt a longer time.

This immenſe quantity of marine foſſils found in ſo many places, proves that they could not have been tranſported thither by the deluge; for if theſe ſhells had been brought on the earth by a deluge, the greateſt part would have remained on the ſurface of the earth, or at leaſt would not have entered to the depth of ſeven or eight hundred feet in the moſt ſolid marble.

In all quarries theſe ſhells form a ſhare of the internal part of the ſtone, ſometimes externally covered with ſtalactites, which is much leſs ancient matter than ſtone, which contains ſhells. Another proof this happened not by a deluge is, that bones, horns, claws, &c. of land animals, are found but very rarely, and not at all in marble and other hard ſtone; whereas if it was the effect of a deluge, where all muſt have periſhed, we ſhould meet with the remains of land animals as well as thoſe of the ſea.

It is a vain ſuppoſition to pretend that all the earth was diſſolved at the deluge, nor can we give any foundation to ſuch idea, but by ſuppoſing a ſecond miracle, to give the water the property of a univerſal diſſolvent. Beſides, what annihilates the ſuppoſition and renders it even contradictory is, that if all matters were diſſolved by that water, yet ſhells have not been ſo, ſince we find them entire and well preſerved in all the maſſes which are ſaid to have been diſſolved; this evidently proves that there never was ſuch diſſolution, and that the arrangement of the parallel ſtrata was not made in an inſtant, but by ſucceſſive ſediments: for it is evident to all who will take the trouble of obſerving, that the arrangement of all the materials which compoſe the globe, is the work of the waters. The queſtion therefore is only whether this arrangement was made at once, or in a length of time: now we have ſhewn it could not be done all at once, becauſe the materials have not kept the order of ſpecific weight, and there has not been a general diſſolution; therefore this arrangement muſt have been produced by ſediments depoſited in ſucceſſion of time; any other revolution, motion, or cauſe, would have produced a very different arrangement. Beſides, particular revolutions, or accidental cauſes could not have produced a ſimilar effect on the whole globe.

Let us ſee what the hiſtorian of the Academy ſays on this ſubject, anno 1718, p. 3. "The numerous remains of extenſive inundations, and the manner in which we muſt conceive mountains to have been formed, ſufficiently proves that great revolutions have happened to the ſurface of the earth. As far as we have been able to penetrate we find little elſe but ruins, wrecks, and vaſt bodies heaped up together and incorporated into one maſs, without the ſmalleſt appearance of order or deſign. If there is ſome kind of regular organization in the terreſtrial globe it is deeper than we have been able to examine, and all our reſearches muſt terminate in digging among the ruins of the external coat, but which will ſtill find ſufficient employment for our philoſophers.

" M. de Juſſieu found in the environs of St. Chaumont a great quantity of ſlaty or foliated ſtones, every foliage of which was marked with the impreſſion of a branch, a leaf, or the fragment of a leaf of ſome plant: the repreſentations of leaves were exactly extended as if they had been carefully ſpread on the ſtone by the hand; this proves they had been brought thither by the water which always keeps leaves in that ſtate: they were in different ſituations, ſometimes two or three together. It may eaſily be ſuppoſed that a leaf depoſited by water upon ſoft mud, and afterwards covered with another layer of mud, imprints on the upper the image of one of its two ſurfaces, and on the under the image of the other, and on being hardened and petrified would appear to have taken different impreſſions: but, however natural this ſuppoſition may be, the fact is not ſo, for the two laminæ of ſtone bear impreſſions of the ſame ſide of the leaf, the one in alto, the other in bas relief. It was M. Juſſieu who made theſe obſervations on the figured ſtones of St. Chaumont; to him we ſhall leave the explication, and paſs to objects which are more general and intereſting.

"All the impreſſions on the ſtones of St. Chaumont are of foreign plants; they are not to be found in any part of France, but only in the Eaſt Indies or the hot climates of America; they are for the moſt part capillary plants, generally of the ſpecies of fern, whoſe hard and compact coat renders them more able to imprint and preſerve themſelves. Some leaves of Indian plants imprinted on the ſtones of Germany appeared aſtoniſhing to M. Leibnitz, but here we find the ſame wonderful affair infinitely multiplied.

tiplied. There even ſeems in this reſpect to be an unaccountable deſtination of nature, for in all the ſtones of St. Chaumont not a ſingle plant of the country has been found.

“ It is certain, by the number of foſſil-ſhells in the quarries and mountains, that this country, as well as many others, muſt have formerly been covered with the ſea. But how has the American or Indian ſea reached thither? To explain this, and many other wonderful phenomena, it may be ſuppoſed, with much probability, that the ſea originally covered the whole terreſtrial globe: but this ſuppoſition will not hold good, becauſe how were terreſtrial plants to exiſt? it evidently, therefore, muſt have been great inundations which have conveyed the plants of one country into the others.

“ M. de Juſſieu thinks, that as the bed of the ſea is continually riſing in conſequence of the mud and ſand which the rivers inceſſantly convey there, the ſea, at firſt confined between natural dykes, ſurmounted them and was diſperſed over the land, and that the dykes were themſelves undermined by the waters and overthrown therein. In the earlieſt time of the formation of the earth, when no one thing had taken a regular form, prodigious and ſudden revolutions might then have been made, of which we no longer have examples, becauſe the whole is now in ſuch a permanent ſtate, that the changes muſt be inconſiderable and by degrees.

By ſome of theſe great revolutions the Eaſt and Weſt Indian ſeas may have been driven to Europe, and carried with them foreign plants floating on its waters, which they tore up in their road and depoſited gently in places where the water was but ſhallow and would ſoon evaporate.

ARTICLE IX.

ON THE INEQUALITIES OF THE SURFACE OF THE EARTH.

THE inequalities which are on the ſurface of the earth, and which might be regarded as an imperfection to its figure, are neceſſary to preſerve vegetation and life on the terreſtrial globe. To be aſſured of this, it is only requiſite to conceive what the earth would be if it was even and regular. Inſtead of agreeable

able hills, from whence pure ſtreams of waters flow, to ſupport the verdure of the earth ; inſtead of thoſe rich and flouriſhing meadows, where plants and animals find agreeable ſubſiſtence ; a diſmal ſea would cover the whole globe, and the earth deprived of all its valuable qualities, would only remain an obſcure and forſaken planet, at beſt only deſtined for the abode of fiſhes.

But independent of moral conſiderations, which ſeldom form a proof in philoſophy, there is a phyſical neceſſity why the earth muſt be irregular on its ſurface ; for, ſuppoſing it was perfectly regular in its origin, the motion of the waters, the ſubterraneous fires, the wind, and other external cauſes, would, in courſe of time, have neceſſarily produced irregularities ſimilar to thoſe now ſeen.

The greateſt inequalities next to the elevations of mountains, are the depths of the ocean ; this depth is very different even at great diſtances from land ; it is ſaid, there are parts above a league deep, but thoſe are few, and the moſt general depths are from 60 to 150 fathoms. The gulphs bordering on the coaſts are much leſs deep, and the ſtraits are generally the moſt ſhallow.

To ſound the depths of the ſea, a piece of lead of 30 or 40lb. is made uſe of faſtened to a ſmall cord; this is a good method for common depths, but is not to be depended upon when the depth is conſiderable; becauſe the cord being ſpecifically lighter than the water, after it has deſcended to a certain degree, the weight of the lead and that of the cord is no more than a like volume of water; then the lead deſcends no longer, but moves in an oblique line, and floats at the ſame depth: to ſound great depths therefore an iron chain is requiſite, or ſome ſubſtance heavier than water. It is very probable that for want of conſidering this circumſtance, navigators tells us that the ſea in many places has no bottom.

In general, the profundities in open ſeas increaſe or diminiſh in a pretty uniform manner, and commonly the farther from ſhore the greater the depth; yet this is not without exception, there are places in the midſt of the ſea where ſhoals are found, as at Abrolhos in the Atlantic; and others where there are banks of a very conſiderable extent, as are daily experienced by the navigators to the Eaſt Indies.

So likewiſe along ſhore the depths are very unequal, nevertheleſs we may lay it down as a certain rule, that the depth there is always proportionate to the height of that ſhore. It is the ſame in great rivers, where the high ſhores always announce a great depth.

It is more eaſy to meaſure the heights of mountains, whether by means of practical geometry, or by the barometer. This inſtrument gives the height of a mountain very exactly, eſpecially in a country where its variation is not conſiderable, as at Peru, and under the other parts of the equator. By one or other of theſe methods, the height of moſt eminences have been meaſured; for example, it has been found that the higheſt mountains of Switzerland are about 1600 fathoms higher than Canigau, which is one of the moſt elevated of the Pyrennees; thoſe mountains appear to be the higheſt in Europe, ſince a great quantity of rivers flow from them, which carry their water into very remote and different ſeas, as the Po, which flows into the Adriatic; the Rhine, which loſes itſelf in the ſands in Holland; the Rhone, which falls into the Mediterranean; and the Danube, which goes to the Black Sea. Theſe four rivers, whoſe mouths are ſo remote from each other, all derive a part of their waters from Mount Saint Godard and the neighbouring mountain, which proves that this place is the higheſt in all Europe. The higheſt mountains in Aſia are Mount Taurus, Mount Imaus, Caucaſus, and the mountains of Japan, all which are loftier than thoſe of Europe; the mountains in Africa, as the Great Atlas, and the Mountains of the Moon, are at leaſt as high as thoſe in Aſia, and the higheſt of all are in South America, particularly thoſe of Peru, which are more than 3000 fathoms above the level of the ſea. In general the mountains between the tropics are loftier than thoſe of the temperate zones, and theſe more than the frigid zones, ſo that the nearer we approach the equator, the greater are the inequalities of the earth. Theſe inequalities, although very conſiderable with reſpect to us, are ſcarcely any thing when conſidered with reſpect to the whole globe. Three thouſand fathom difference to 3000 leagues diameter, is but one fathom to a league, or one foot to 2200 feet, which on a globe of 2½ feet diameter, does not make the 16th part of a French line. Thus the earth, which appears to us croſſed and interſected by the enormous height of mountains, and by a frightful depth of ſea, is nevertheleſs, relative to its ſize, but ſlightly furrowed with irregularities, ſo very trifling, that they can caufe no difference to the general figure of the globe. In continents the mountains are continued and form chains. In iſlands, they are more interrupted, and generally raiſed above the ſea, in the forms of cones or pyramids, and are called peaks. The peak of Teneriffe, in the iſland of Fer, is one of the higheſt mountains on the earth; it is near a league and a half perpendicular above the level of the ſea; the peak of St. George, in one of the Azores, and the peak of Adam, in the iſland of Ceylon, are alſo very lofty. Theſe peaks are compoſed of rocks, heaped one upon the other, and they vomit from their ſummits fire, cinders, bitumen, minerals, and ſtones. There are iſlands which are only tops of mountains, as of St. Helena, Aſcenſion, moſt of the Azores, and Canaries. We muſt remark, that in moſt of the iſlands, promontories, and other projecting lands in the ſea, the middle is always the higheſt; and they are generally ſeparated by chains of mountains, which divide them in their greateſt length, as (Granſbain) the Grampian mountains in Scotland, which extend from eaſt to weſt, and divide Great Britain into two parts. It is the ſame with the iſlands of Sumatra, Lucca, Borneo, Celebes,

Cuba,

Cuba, St. Domingo, and the peninſula of Malaya, &c. and alſo Italy, which is traverſed through its whole length by the Apennine mountains.

Mountains, as we find, differ greatly in height; the hills are loweſt, after them come the mountains of a moderate height, which are followed by a third rank ſtill higher, which, like the preceding, are generally loaded with trees and plants, but which furniſh no ſprings except at their bottoms. In the higheſt mountains we find only ſand, ſtones, flints, and rocks, whoſe ſummits often riſe above the clouds. Exactly at the foot of theſe rocks there are ſmall ſpaces, plains, hollows, and kinds of vallies, where the rain, ſnow, and ice remain, and form ponds, moraſſes, and ſprings, from whence rivers derive their origin.

The form of mountains is alſo very different: ſome form chains whoſe height is nearly equal in a long extent of ſoil, others are divided by deep vallies; ſome are regular, and others as irregular as poſſible; and ſometimes in the middle of a valley or plain, we find a little mountain. There are alſo two ſorts of plains, the one in the low lands, the other in mountains. The firſt are generally divided by ſome large river: the others, though of a very conſiderable extent, are dry, and at fartheſt have only a ſmall rivulet. Theſe plains on mountains are often very high, and difficult of acceſs; they form countries above other countries, as in Auvergne, Savoy, and many other high places: the ſoil is firm, and produces much graſs, and odoriferous plants, which render theſe plains the beſt paſture in the world.

The ſummits of high mountains are compoſed of rocks of different heights, which reſemble from a diſtance the waves of the ſea. It is not on this obſervation alone we can rely that the mountains have been formed by the waves, I only relate it becauſe it accords with the reſt: but that which evidently proves that the ſea once covered and formed mountains, are the ſhells and other marine productions found throughout in ſuch great quantities, that it is not poſſible for them to have been tranſported by the ſea into ſuch remote continents, and depoſited to ſuch conſiderable depths; to this may be added, the horizontal and parallel ſtrata every where met with, and which can only have been formed by the waters. The compoſition even of the hardeſt matters, as ſtone and marble, prove they had been reduced into fine powder before their formation, and precipitated to the bottom of the water in form of a ſediment: it is alſo proved by the exactneſs with which foſſil-ſhells are moulded in thoſe matters in which they are found; the inſide of theſe ſhells are abſolutely filled with the ſame matters as that in which they are encloſed; the correſponding angles of mountains and hills, which no other cauſe than the currents of the ſea could have been able to form; the equality in the height of oppoſite hills, and beds of different matters, formed at the ſame levels, and, in ſhort, the direction of mountains, whoſe chains extend in length in the ſame direction as the waves of the ſea extend, inconteſtibly demonſtrate the fact.

With reſpect to the depths on the ſurface of the earth, the greateſt, without contradiction, are the depths of the ſea; but as they do not preſent themſelves to our ſight, and as we can only judge of them by the plumb line, we ſhall only ſpeak of thoſe which appear on dry land, ſuch as the deep vallies between mountains, the precipices between rocks, the abyſſes perceived from the tops of mountains, as tbe abyſs of Mount Ararat, the precipices of the Alps, the vallies of the Pyrennees, &c.

Theſe depths are a natural conſequence of the elevation of mountains; they receive the waters and the earth which flow from the mountains; and the ſoil is generally very fertile, and are fully inhabited.

The precipices which are between rocks are frequently formed by the ſinking of one ſide, the baſe of which ſometimes gives way more on one ſide than the other, by the action of the air and froſt, which ſplits and divides them, or by the impetuous violence of torrents. But theſe abyſſes, or vaſt and enormous precipices, found at the ſummits of mountains, and to the bottom of which it is not poſſible ſometimes to deſcend, although they are above a mile, or a mile and a half round, have been formed by the fire. Theſe were formerly the funnels of volcanos, and all the matter which is there deficient has been ejected by the action and exploſion of theſe fires, which are ſince extinguiſhed through a defect of combuſtible matter. The abyſs of Mount Ararat, of which M. Tournefort gives a deſcription in his voyage to the Levant, is ſurrounded with black and burnt rocks, as one day the abyſſes of Etna, Veſuvius, and other volcanos, will be, when they have conſumed all the combuſtible matters they include.

In Plots' Natural Hiſtory of Staffordſhire, in England, a kind of gulph is ſpoken of which has been ſounded to the depth of 2600 perpendicular feet without meeting with any water, or the bottom being found, as the rope was not of ſufficient length to reach it.

Greateſt cavities and deepeſt mines are generally in mountains, and they never deſcend to a level with the plains, therefore, by theſe cavities we are only acquainted with the inſide of a mountain, and not with the internal part of the globe itſelf.

Beſides, theſe depths are not very conſiderable. Ray aſſerts that the deepeſt mines are not above half a mile deep. The mine of Cotteberg, which in the time of Agricola paſſed for the deepeſt of all known mines, was only 2500 feet perpendicular. It is evident there are holes in certain places, as that in Staffordſhire, or Pool's Hole, in Derbyſhire, the depth of which is perhaps greater; but all this is nothing in compariſon with the thickneſs of the globe.

If the Kings of Egypt, inſtead of having erected pyramids, and raiſed ſuch ſumptuous monuments of their riches and vanity, had been at the ſame expence to ſound the earth, and make a deep excavation to the depth of a league, they, perhaps, might have found ſubſtances which would have amply recompenſed the trouble, labour, and expence, or at leaſt we ſhould have received information on the matters of which the internal part of the globe is compoſed, which might have been very uſeful, and which we at preſent have not.

But let us return to the mountains; the higheſt are in the ſouthern countries, and the nearer we approach the equator, the more inequalities we find on the ſurface of the globe. This is eaſy to prove, by a ſhort enumeration of the mountains and iſlands.

In America, the chain of the Cordeliers, the higheſt mountains of the earth, is exactly under the equator, and extends on the two ſides far beyond the tropic circles.

In Africa, the higheſt mountains of the Moon, and Monomotapa, the great and the little Atlas, are under the equator, or not far from it.

In Aſia, Mount Caucaſus, the chain of which extends under different names as far as the mountains of China, is nearer the equator than the poles.

In Europe, the Pyrennees, the Alps, and mountains of Greece, which are only the ſame chain, are ſtill leſs diſtant from the equator than the poles.

Now theſe mountains which we have enumerated, are all higher, more conſiderable and extended in length and breadth than the mountains of the northern countries.

With reſpect to their direction, the Alps form a chain which croſſes the whole continent from Spain to China. Theſe mountains begin at the ſea coaſt of Galicia, reach to the Pyrennees, croſs France, by Vivares, and Auvergne, paſs through Italy, and extend into Germany, beyond Dalmatia, as far as Macedonia; from thence they join with the mountains of Armenia, Caucaſus, Taurus, Imaus, and extend as far as the Tartarian ſea. So likewiſe Mount Atlas traverſes the whole continent of Africa, from weſt to eaſt, from the kingdom of Fez to the Straits of the Red Sea; and the Mountains of the Moon have the ſame direction.

But in America, the direction is quite contrary, and the chains of the Cordeliers and other mountains extend from ſouth to north more than from eaſt to weſt.

What we have now ſaid on the great eminences of the earth, may alſo be obſerved on the greateſt depths of the ſea. The vaſt and higheſt ſeas are nearer the equator than the poles; and there reſults from this obſervation, that the greateſt inequalities of the globe is in the ſouthern climate. Theſe irregularities on the ſurface of the earth, are the cauſes of an infinity of extraordinary effects: for example, between the Indus and the Ganges, there is a large peninſula, which is divided through its middle by a chain of high mountains called the Gate, and which extends from north to ſouth, from the extremities of Mount Caucaſus to Cape Comorin; on one is the coaſt of Malabar, and the other Coromandel; on the ſide of Malabar, between this chain of mountains and the ſea, the ſummer ſeaſon laſts from September to April, during which the ſky is ſerene and dry; on the other ſide the Coromandel, the above period is their winter, and it rains every day plentifully; and from the month of April to the month of September is their ſummer, whereas it is winter in Malabar; inſomuch, that in many places, which are ſcarcely 20 miles diſtant, we may, by croſſing the mountains, change ſeaſons. It is ſaid that the ſame thing takes place at Razalgat in Arabia, and at Jamaica, which is divided through its middle by a chain of mountains, whoſe direction is from eaſt to weſt, and that the plantations to the ſouth of theſe mountains feel the ſummer heat, at the time thoſe to the north endure the rigor of winter.

Peru, which is ſituated under the line, and extends about a thouſand leagues to the ſouth, is divided into three long and narrow parts, theſe the natives call Lanos, Sierras, and Andes. The Lanos, which comprehends the plains, extends along the coaſt of the South Sea: the Sierras are hills with ſome vallies, and the Andes are the famous Cordeliers, the higheſt mountains that are known. The Lanos is about ten leagues in breadth; in many places the Sierras are twenty leagues broad, and the Andes in ſome places more and in ſome leſs. The breadth is from eaſt to weſt, and the length from north to ſouth. This part of the world is remarkable for the following particulars: firſt, In the Lanos the wind almoſt conſtantly blows from the ſouth-weſt, which is contrary to what happens in the torrid zone: ſecondly, It never rains nor thunders in the Lanos, although there is plenty of dew: thirdly, It almoſt continually rains in the Andes: fourthly, In the Sierras, between the Lanos and the Andes, it rains from September to April.

It was for a long time ſuppoſed, that the chains of the high mountains run from weſt to eaſt, till the contrary was found in America. But no perſon before M. Bourguet diſcovered the ſurpriſing regularity of the ſtructure of thoſe great maſſes: he found, (after having croſſed the Alps 30 times in 14 different parts of it, twice over the Apennine mountains, and made divers tours in the environs of theſe mountains, and of Mount Jura,) that all mountains are formed nearly after the manner of works of a fortification. When the body of the mountain runs from eaſt to weſt, it forms prominences, which face the north and ſouth; this wonderful regularity is ſo ſtriking in vallies, that we ſeem to walk in a very regular covered way; if, for example, we travel in valley from north to ſouth, we perceive that the mountain on the right forms projections which front the eaſt, and thoſe of the mountain on the left front the weſt, ſo that the ſaliant angles of one ſide reciprocally anſwer the returning angles of the other, which are always alternatively oppoſed to them. The angles which mountains form in great vallies are leſs acute, becauſe the direction is leſs ſteep, and they are farther diſtant from each other. In plains they are not ſo perceptible, except by the banks of rivers, which are generally in the middle of them, and whoſe natural windings anſwer the moſt advanced angles or ſtriking projections of the mountains. It is aſtoniſhing ſo viſible a thing was ſo long unobſerved, for when in a valley the inclination of one of the mountains which border it is leſs ſteep than that of the other, the river takes its courſe much nearer the ſteepeſt mountain, and does not flow through its middle.

To theſe obſervations we may join other particular ones, which confirm them; for example, the mountains of Switzerland are much more ſteep, and their direction much greater on the ſouth ſide than on the north, and on the weſt ſide than on the eaſt. This may be perceived in the mountains of Gemmi, Briſa, and almoſt every other mountain in this country. The higheſt are thoſe which ſeparate Valleſia and the Griſons from Savoy, Piedmont and Tirol. Theſe countries are only a continuation of theſe mountains, the chain of which extends to the Mediterranean, and continues even pretty far under the ſea. The Pyrennees are alſo only a continuation of that vaſt mountain which begins in Upper Valeſia, and whoſe branches extend very far to the weſt and ſouth, preſerving throughout the ſame great height, whereas on the ſide of the north and of the eaſt theſe mountains grow lower by degrees, till they become plains; as we ſee by the large tract which the Rhine and Danube water before they reach their mouths, whereas the Rhone deſcends with rapidity towards the ſouth into the Mediterranean. The ſame obſervation is found to hold good in the mountains of England and Norway; but the part of the world where this is moſt evidently ſeen is at Peru and Chili; the Cordeliers are cut very ſharply on the weſtern ſide, the length of the Pacific Ocean, whereas on the eaſtern ſide they lower by degrees into large plains, watered by the greateſt rivers of the world *.

M. Bourguet, to whom we owe this great diſcovery of the correſpondence of the angles of mountains, terms it "*The Key of the Theory of the Earth*;" nevertheleſs, it appears to me, that if he had conceived all the importance of it, he would more ſucceſsfully have made uſe of it, by connecting it with ſuitable facts, and would have given a more probable theory of the earth; whereas in his treatiſe he preſents only the ſkeleton of an hypothetical ſyſtem, moſt of the concluſions of which are falſe or precarious. The theory we have given turns on four principal facts, which cannot be doubted, after the proofs have been examined on which they are founded. The firſt is, that the earth is every where, and to conſiderable depths, compoſed of parallel ſtrata, and matters which have formerly been in a ſtate of ſoftneſs: the ſecond, that the ſea has for ages covered the earth which we now inhabit; the third, that the tides and other motions of the waters produce inequalities at the bottom of the ſea; and the fourth, that the mountains have taken their form and the correſpondent direction from the currents of the ſea.

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* See Phil. Tranſ. Abr. vol. VI. part ii. p. 153.

After having read the proofs which the following articles contain, it may be determined, whether I was wrong to aſſert, that theſe circumſtances ſolidly eſtabliſhed alſo aſcertains the truth of the theory of the earth. What I have ſaid on the formation of mountains has no need of a more ample explanation; but as it might be objected that I do not aſſign a reaſon for the formation of the peaks or points of mountains,

tains, no more than for ſome other particular circumſtances, ſhall add the obſervations and reflections which I have made on this ſubject.

I have endeavoured to form a clear and general idea of the manner in which the different matters that compoſe the earth are arranged, and it appears to me, they may be reduced into two general claſſes: the firſt includes all the matters we find placed in ſtrata or beds horizontally or regularly inclined; and the ſecond comprehends all matters formed in maſſes, or in veins, either perpendicular or irregularly inclined. In the firſt claſs are included ſands, clays, granate, flints, free-ſtone, coals, ſlates, marls, chalks, calcinable ſtones, marbles, &c. In the ſecond I rank metals, minerals, cryſtals, precious ſtones and ſmall flints: theſe two claſſes generally comprehend all the known materials of the earth. The firſt owe their origin to the ſediments carried away and depoſited by the ſea, and ſhould be diſtinguiſhed into thoſe which, being aſſayed in the fire, calcine and are reduced into lime, and thoſe which fuſe and are convertible into glaſs. The materials of the ſecond claſs are all vitrifiable, excepting thoſe which the fire entirely conſumes by inflammation.

In the firſt claſs we diſtinguiſh two kinds of ſands, the one which is more abundant than any other matter of the globe, is vitrifiable, or rather is only fragments of actual glaſs; the other, whoſe quantity is much leſs, is calcinable, and muſt be looked upon as the powder of ſtone, and which differs only from gravel by the ſize of the grains. The vitrifiable ſand is, in general, depoſited in beds, but are often interrupted by maſſes of free-ſtone, granate, and flint; and ſometimes theſe matters are alſo in banks of great extent.

By examining theſe vitrifiable matters, we find only a few ſea ſhells there, and thoſe not placed in beds, but diſperſed about as if thrown there by chance. For example, I have never ſeen them in free-ſtone; that ſtone which is very plenty in certain places, is only compoſed of ſandy parts, which are re-united, and are only met with in ſandy ſoils; and the quarries of it are generally in peaked hills and in divided eminences. We may work theſe quarries in all directions, and if they are in large beds, they are much farther from each other than in quarries of calcinable ſtone or marble. Blocks of free-ſtone may be cut of all dimenſions and in all directions, although it is difficult to work, it nevertheleſs has but a degree of hardneſs ſufficient to reſiſt powerful ſtrokes without ſplitting: for friction eaſily reduces it into ſand, excepting certain black pieces found therein, and which are ſo very hard, that the beſt files cannot touch them. Rock is vitrifiable as free-ſtone, and of the ſame nature, only it is harder, and the parts more connected. This alſo contains many hard pieces, as may eaſily be remarked on the ſummits of high mountains, which cuts and tears the ſhoes of travellers. This rocky ſtone, which is found at the top of high mountains, and which I look upon as a kind of granate, contains a great quantity of talky leaves, and is ſo hard as not to be worked but by an infinite deal of labour.

I have narrowly examined theſe ſharp pieces which are found in free-ſtone and rock, and have diſcovered it to be a metallic matter melted and calcined by a very violent fire, and which perfectly reſembles certain ſubſtances thrown out by the volcanos, of which I ſaw a great quantity when I was in Italy, where the people called them Schiarri. They are very heavy black maſſes, on which neither fire, water, nor the file, can make any impreſſion, and the matter of which is different from that of the lava; for this is a kind of glaſs, whereas the other appears to be more metallic than vitreous. The ſharp pieces in free-ſtone and rock, reſemble greatly this firſt matter, which ſeems ſtill to prove that all theſe matters have been formerly liquefied by fire.

We ſometimes ſee on the upper parts of mountains, a prodigious quantity of blocks of this mixed rock; their poſition is ſo irregular, that they appear to have been thrown there by chance, and it might be thought they had fallen from ſome neighbouring height, if the places where they are found were not raiſed above the other parts. But their vitrifiable nature, and their angular and ſquare figures, like thoſe of free-ſtone, diſcovers them to be of one common origin. Thus in the great beds of vitrifiable ſand, blocks of free-ſtone and rock are formed, whoſe figure and ſituation do not exactly follow the horizontal poſition of theſe ſtrata. The rain has, by degrees, carried away from the ſummit of the hills and mountains the ſand which at firſt covered them, and then began to furrow and cut thoſe hills into the ſpaces which are found between the nucleus in free-ſtone, as the hills of Fontainbleau are interſected. Each hilly point anſwers to a nucleus in a quarry of free-ſtone, and each interval has been excavated and looſened by the rain, which has cauſed the ſand, they at firſt contained, to flow into the vallies; ſo likewiſe the higheſt mountains, whoſe ſummits are compoſed of rocks, and terminated by the angular blocks of granate, have formerly been covered with vitrifiable ſand, and the rain having carried away the ſand which covered them, they remained on the top of the mountains in the poſition they were formed. Theſe blocks generally preſent points; they increaſe in ſize in proportion as they deſcend: one block often reſts upon another, the ſecond upon a third, and ſo on, leaving irregular intervals between them: and as in time the rain waſhed away all the ſand which covered theſe different parts on the top of the high mountains, they would remain naked, forming larger or leſſer points; and this is the origin of the peaks or horns of mountains.

For ſuppoſing, as it is eaſy to prove, by the marine productions we find there, that the chain of the Alps was formerly covered by the ſea, and that above this chain there was a great thickneſs of vitrifiable ſand, which rendered the whole mountains a flat and level country: in this depth of ſand, there would neceſſarily be formed granate, free-ſtone, flint, and all matters which take their origin and figure in ſand, nearly in a ſimilar manner to that of the chryſtalliſation of ſalts. Theſe blocks once formed would ſupport their original poſitions, after the rains and torrents had carried away the ſand which ſurrounded them, and being left bare, formed all thoſe peaks or pointed eminences we ſee in ſo many places. This is alſo the origin of thoſe high and detached rocks found in China and other countries, as in Ireland, where they are called the Devil's ſtones, and whoſe formation, as well as that of the peaks of mountains, had hitherto appeared ſo difficult to explain; nevertheleſs, the explanation which I have given is ſo natural, that it directly preſents itſelf to the mind of thoſe who examine theſe objects, and I muſt here quote what Father Tatre ſays, " From Yanchu-in-yen, we came to Hoytcheou, and on the road met with ſomething particular, rocks of an extraordinary height, of the ſhape of a large ſquare tower, and ſituate in the midſt of vaſt plains; it is not known how they came there, nor can I ac-

I account for it, unleſs by ſuppoſing they were formerly mountains, from which the rain having waſhed away the earth that ſurrounded them, has thus left the rocks entirely bare. What ſtrengthens this conjecture is, that we ſaw ſome which towards the baſe are ſtill covered with earth to a conſiderable height."

The ſummit of the higheſt mountains is compoſed of rocks, of granate, free-ſtone, and other hard and vitrifiable matters, and this often as deep as two or three hundred fathoms; below which we often meet with quarries of marble or hard ſtone filled with foſſil-ſhells, and whoſe matter is calcinable, as may be remarked at Great Chartreuſe, in Dauphiny, and on Mount Cenis, where the ſtone and marble which contains ſhells, are ſome hundred fathoms below the ſummits, points and peaks of high mountains; although theſe ſtones are more than a thouſand fathom above the level of the ſea. Thus mountains, whereon we ſee points or peaks, are generally vitrifiable rock, and thoſe whoſe ſummits are flat, moſtly contain marble and hard ſtones filled with marine productions. It is the ſame with reſpect to hills, for thoſe containing granate, or free-ſtone, are moſtly interſected with points, eminences, cavities, depths, and ſmall intermediate valleys; on the contrary, thoſe which are compoſed of calcinable ſtone are nearly equal in height, and are only interrupted by greater and more regular vallies, whoſe angles are correſpondent; and they are crowned with rocks whoſe poſition is regular and level.

Whatever difference may appear at firſt between theſe two ſpecies of mountains, their forms proceed from the ſame cauſe, as we have already obſerved; only it may be remarked, that the calcinable ſtones have not undergone any alteration nor change ſince the formation of the horizontal ſtrata: whereas thoſe of vitrifiable ſand have been changed and interrupted by the poſterior production of rocks and angular blocks formed within this ſand. Theſe two kind of mountains have cracks which are almoſt always perpendicular in thoſe of calcinable ſtones; but thoſe of granate and free-ſtone appear to be a little more irregular in their direction. It is in theſe cracks metals, minerals, cryſtals, ſulphurs, and all matters of the ſecond claſs are found, and it is below theſe cracks that the water collects to penetrate the earth, and from thoſe veins of water which are every where found below the ſurface.

ARTICLE X.

OF RIVERS.

WE have before ſaid that, generally ſpeaking, the greateſt mountains are in iſlands and in the projections in the ſea. That in the old continent the greateſt chains of mountains are directed from weſt to eaſt, and that thoſe which incline towards the north or ſouth are only branches of theſe principal chains; we ſhall likewiſe find that the greateſt rivers are directed as the greateſt mountains, and that there are but few which follow the courſe of the branches of thoſe mountains. To be aſſured of this, we have only to look on a common globe, and trace the old continent from Spain to China. We ſhall find, by beginning at Spain, that the Vigo, Douro, Tagos, and Guadiana run from eaſt to weſt, and the Ebro from weſt to eaſt, and that there is not one remarkable river whoſe courſe is directed from ſouth to north, or from north to ſouth, although Spain is entirely ſurrounded by the ſea on the weſt ſide, and almoſt ſo on the north. This obſervation on the direction of rivers in Spain not only proves that the mountains in this country are directed from weſt to eaſt, but alſo that the ſouthern lands, which border on the ſtraits, are higher than the coaſts of Portugal; and on the northern coaſt, that the mountains of Galicia, the Aſturias, &c. are only a continuation of the Pyrennees, and that it is this elevation of the country, as well north as ſouth, which does not permit the rivers to run into the ſea that way.

It will alſo be ſeen, by looking on the map of France, that there is only the Rhone which runs from north to ſouth, and nearly half its courſe, from the mountains to Lyons, is directed from the eaſt towards the weſt; but that on the contrary all the other great rivers, as the Loir, the Charantee, the Garonne, and even the Seine, have a direction from eaſt to weſt.

It will be likewiſe perceived, that in Germany there is only the Rhine, which like the Rhone ſhapes the greateſt part of its courſe from north to ſouth, but that the others, as the Danube, the Drave, and all the great rivers which fall into them, flow from the weſt to eaſt into the Black Sea.

It will be perceived that this Black Sea, which ſhould rather be conſidered as a great lake, has almoſt three times more extent from eaſt to weſt than from north to ſouth, and conſequently its direction is ſimilar to the rivers in general. It is the ſame with the Mediterranean, whoſe length from eaſt to weſt is about ſix times greater than from north to ſouth.

The Caſpian ſea, according to the chart drawn by the order of Czar Peter I. has more extent from the ſouth to the north than from eaſt to weſt; whereas in the ancient charts it appears almoſt round, or rather more broad from eaſt to weſt than from ſouth to north; but if we conſider the lake Aral as a part of the Caſpian ſea, from which it is ſeparated only by plains of ſand, we ſhall find the length is from the weſtern coaſt of the Caſpian ſea as far as the greateſt border of Lake Aral.

So likewiſe the Euphrates, the Perſian gulph, and almoſt all the rivers in China run from weſt to eaſt; all the rivers in Africa beyond Barbary flow from eaſt to weſt, or from weſt to eaſt, and there are only the rivers of Barbary and the Nile, which flow from ſouth to north. There are, in fact, great rivers in

Aſia which partly run from north to ſouth, as the Wolga, the Don, &c. but by taking the whole length of their courſe, we find that they only turn from the ſouth to run into the Black and Caſpian ſeas, which are only inland lakes.

It may therefore in general be ſaid, that in Europe, Aſia, and Africa, the rivers, and other mediterranean waters, extend more from eaſt to weſt than from north to ſouth, which proceeds from the chains of mountains being for the moſt part ſo directed, and that the whole continent of Europe and Aſia is broader in this direction than the other; for there are two modes of conſidering the direction of mountains. In a long and narrow continent like South America, in which there is only one principal chain of mountains which ſtretches from ſouth to north, the river not being confined by any parallel range, neceſſarily runs perpendicular to the courſe of the mountains, that is from eaſt to weſt, or from weſt to eaſt; in fact, it is in this direction all the rivers of America flow. In the old as well as the new continent moſt of the waters have their greateſt extent from weſt to eaſt, and moſt of the rivers flow in this direction; but yet this ſimilar direction is produced by different cauſes; for inſtance, thoſe in the old continent flow from eaſt to weſt, becauſe they are bounded by mountains whoſe direction is from weſt to eaſt; whereas thoſe in America preſerve the ſame courſe from there being only one chain of mountains that extends from north to ſouth.

In general rivers run through the centre of vallies, or rather the loweſt ground betwixt two oppoſite hills or mountains; if the two hills have nearly an equal inclination the river will be nearly in the middle of the intermediate valley, let the valley be broad or narrow. On the contrary, if one of the hills has a more ſteep inclination than the other, the river will not be in the middle of the valley, but much nearer the hill whoſe inclination is greateſt, and that too in proportion to the ſuperiority of its declivity: in this caſe, the loweſt ground is not in the middle of the valley, but inclines towards the higheſt hill, and which the river muſt neceſſarily occupy. In all places where there is any conſiderable difference in the height of the mountains, the rivers flow at the foot of the ſteepeſt hills, and follow them throughout all their directions, never quttting their courſe while they maintain the ſuperiority of height. In the length of time, however, the ſteepeſt hills are diminiſhed by the rain acting upon them with a greater degree of force, proportionate to their height, and conſequently carry away the ſand and gravel in more conſiderable quantities, and with greater violence ; the river is then conſtrained to change its bed, and ſeek the loweſt part of the valley : to this may be added, that as all rivers overflow at times, they tranſport and depoſit mud and ſand in different places, and that ſands often accumulate in their own beds, and cauſe a ſwell of the water, which changes the direction of its courſe. It is very common to meet in vallies with a great number of old channels of the river, particularly if it is ſubject to frequent inundations, and carries off much ſand and mud.

In plains and large vallies, where there are great rivers, the beds are generally the loweſt part of the valley, but the ſurface of the water is very often higher than the ground adjacent. For example, when a river begins to overflow, the plain will preſently be inundated to a conſiderable breadth, and it will be obſerved that the borders of the river will be covered the laſt ; which proves that they are higher than the reſt of the ground, and that from the banks to a certain part of the plain, there is an inſenſible inclination, ſo that the ſurface of the water muſt be higher than the plain when the river is full. This elevation on the banks of rivers proceeds from the depoſit of the mud and ſand at the time of inundations. The water is commonly very muddy in the great ſwellings of rivers; when it begins to overflow, it runs very gently over the banks, and by depoſiting the mud and ſand purifies itſelf as it advances into the plain; ſo that all the ſoil, which the currents of the river does not carry along, is depoſited on the banks, which raiſes them by degrees above the reſt of the plain.

Rivers are always broadeſt at their mouths; in proportion as we advance in the country, and are more remote from the ſea, their breadth diminiſhes; but what is more remarkable, in the inland parts they flow in a direct line, and in proportion as they approach their mouths the windings of their courſe increaſes. I have been informed by M. Fabry, a ſenſible traveller, who went ſeveral times by land into the weſtern part of North America, that travellers and even the ſavages are ſeldom deceived in the diſtance they are from the ſea if they follow the bank of a large river; when the direction of the river is ſtraight for 15 or 20 leagues, they know themſelves to be a great diſtance from the coaſt; but, on the contrary, if the river winds, and often changes its direction, they are certain of not being far from the ſea. M. Fabry himſelf verified this remark in his travels over that unknown and almoſt uninhabited country. In large rivers there is a conſiderable eddy along the banks, which is ſo much the more conſiderable as the river is leſs remote from the ſea, which may alſo ſerve as a guide to judge whether we are at a great or ſhort diſtance from the mouth; and as the windings of rivers increaſe in proportion as they approach the ſea, it is not ſurpriſing that ſome of them ſhould give way to the water, and be one reaſon why great rivers generally divide into many arms before they gain the ſea.

The motion of the waters in rivers is quite different from that ſuppoſed by authors who attempt to give mathematical theories on this ſubject; the ſurface of a river in motion is not level when taken from one bank to the other, but according to circumſtances the current in the middle is conſiderably higher or lower than the water cloſe to the banks; when a river ſwells by a ſudden melting of ſnow, or when by ſome other cauſe its rapidity is augmented, if the direction of the river is ſtrait, the middle of the water where the current is riſes, and the river forms a convex curve, of a very ſenſible elevation. This elevation is ſometimes very conſiderable; M. Hupeau, an able engineer of bridges, once meaſured the river Avieron, and found the middle was three feet higher than near the bank. This, in fact, muſt happen every time the water has a very great rapidity; the velocity with which it is carried, diminiſhing the action of its weight in the middle of the current, ſo that it has not time to ſink to a level with that near ſhore, and therefore remains higher. On the other hand, near the mouths, it often happens that the water which is near the banks is higher than that of the middle, although the current be ever ſo rapid. This happens wherever the action of the tides is felt in a river, which in great ones often ſenſibly extends as far as one or two hundred leagues from the ſea; it is alſo a well known fact that the current of a river preſerves its motion in the ſea to a conſiderable diſtance; there is, in this caſe, therefore, two contrary motions in a river; the middle, which forms the current, precipitates itſelf towards the ſea, and the action of the tide forms a counter-current, which cauſes the water near the banks to aſcend, while that in the middle deſcends, and as then all the water muſt be carried down by the current in the middle, that of the banks continually deſcends thereto, and deſcends ſo much the more as it is higher, and counteracted with more force by the tide.

There are two kinds of ebbings in rivers; the firſt above-mentioned is a ſtrong power occaſioned by the tide, which not only oppoſes the natural motion of the river, but even forces a contrary and oppoſite current. The other ariſes from an inactive cauſe, ſuch as a projection of land, an iſland, &c. This does not commonly occaſion a very ſenſible counter-current, yet it is ſufficient to impede the progreſs of boats and craft, and neceſſarily produces what is called a dead water, which does not flow like the reſt of the river, but whirls about in ſuch a manner that when boats are drawn therein they require great ſtrength to get them out. Theſe dead waters are very perceptible at the arches of bridges in rapid rivers. The velocity of the water increaſes in proportion as the diameter of the channel through which it paſſes diminiſhes, the impelling force being the ſame;

the velocity of a river, therefore encreaſes at the paſſage of a bridge, in an inverſe proportion of the breadth of the arches to the whole breadth of the river; the rapidity being very conſiderable in coming through the arch, it forces the water againſt the banks, from whence it is reflected with ſuch violence as to form dangerous eddies and whirlpools. In going through the bridge St. Eſprit, the men are forced to be careful not to loſe the ſtream, even after they are paſt the bridge, for if they ſuffer the boat to go either to the right or left it might be driven againſt the ſhore, or forced into the whirling waters, which would be attended with great danger. When this eddy is very conſiderable it forms a kind of ſmall gulph, the middle of which appears hollow and to form a kind of cylindrical cavity, around which the water whirls with rapidity: this appearance of a cylindrical cavity is produced by the centrifugal force which cauſes the water to endeavour to remove itſelf from the centre of the whirlpool. When a great ſwell of water happens the watermen know it by a particular motion; they then ſay the water at the bottom flows quicker than common: this augmentation of rapidity at the bottom, according to them, always announces a ſudden riſe of the water. The motion and weight of the upper water communicates this motion to them; for in certain reſpects we muſt conſider a river as a pillar of water contained in a tube, and the whole channel as a very long canal where every motion muſt be communicated from one end to the other. Now, independent of the motion of the upper waters, their weight alone might cauſe the rapidity of the river to increaſe, and perhaps move it at bottom: for it is known, that by putting many boats at one time into the water, at that inſtant we increaſe the rapidity of the under part of the river, as well as retard that of the upper.

The rapidity of running waters does not exactly, nor even nearly, follow the proportion of the declivity of their channels. One river whoſe inclination is uniform and double that of another, ought, according to appearance, to flow only as rapid again, but in fact it flows much faſter. Its rapidity, inſtead of being doubled, is ſometimes triple, quadruple, &c. This rapidity depends much more on the quantity of water and the weight of the upper waters than on the declivity. When we are deſirous to hollow the bed of a river, we need not equally diſtribute the inclination throughout its whole length, in order to give a greater rapidity, as it is more eaſily effected by making the deſcent much greater at the beginning, than at the mouth where it may almoſt be inſenſible, as we ſee it in natural rivers, and yet they preſerve a rapidity ſo much the greater as the river is fuller of water; in great rivers, where the ground is level, the water does not ceaſe flowing, and even rapidly, not only with its original velocity, but alſo with the addition of that which it has acquired by the action and weight of the upper waters. To render this fact more conceivable, let us ſuppoſe the Seine between the Pont-neuf and Pont-royal to be perfectly level, and ten feet deep throughout: let us then ſuppoſe that the bed of the river below Pont-royal and above Pont-neuf were left entirely dry, the water would inſtantly run up and down the channel and continue to do ſo until it had recovered an equilibrium; for the weight of the water would keep it in motion, nor would it ceaſe flowing until its particles became equally preſſed and have ſunk to a perfect level. The weight of water therefore greatly contributes to its velocity, and this is the reaſon that the greateſt rapidity of the current is neither of the ſurface nor at the bottom of the water, but nearly in the middle of its depth, being preſſed by the action of its weight at its ſurface, and by the re-action from the bottom. Still more, if a river has acquired a great rapidity, it will not only preſerve it in paſſing a level country, but even ſurmount an eminence without ſpreading much on either ſide, or at leaſt without cauſing any great inundation.

We might be inclined to think that bridges, locks, and other obſtacles raiſed on rivers, conſiderably diminiſhes the celerity of the water's courſe; nevertheleſs that occaſions but little difference. Water riſes on meeting with any obſtacle, and having ſurmounted it, the elevation cauſes it to act with more rapidity in its fall, ſo that in fact it ſuffers little or no diminution in its celerity by theſe ſeeming retardments. Sinuoſities, projections, and iſlands, alſo but very little diminiſh the velocity of the courſe of rivers. A conſiderable diminution is produced by the ſinking of the water, and, on the contrary, its augmentation increaſes its velocity; thus if a river is ſhallow the ſtream paſſes ſlowly along, and if deep with a proportionate rapidity.

If rivers were always nearly of an equal fulneſs, the beſt means of diminiſhing their rapidity, and confining them within their banks, would be to enlarge their channel; but as almoſt all rivers are ſubject to increaſe and diminiſh, to confine them we muſt retrench the channel, becauſe in ſhallow waters, if the channel is very broad, the water which paſſes in the middle hollows a winding bed, and when it begins to ſwell follows the direction it took in this particular bed, and ſtriking forcibly againſt the banks of the channel deſtroys them and does great injuries. Theſe effects of the water's fury might be prevented by making, at particular diſtances, ſmall gulphs in the earth; that is, by cutting through one of theſe banks to a certain diſtance in the land. In order that theſe gulphs might be advantageouſly placed, they ſhould be made in the obtuſe angle of the river, for then the current of the water in turning would run into them, and of courſe its velocity would be diminiſhed. This mode might be proper to prevent the fall of bridges in places where it is not poſſible to make bars near the bridge which ſuſtain the action of the weight of the water.

The manner in which inundations are occaſioned merits peculiar attention. When a river ſwells, the rapidity of the water always increaſes till it begins to overflow the banks ; at that inſtant the velocity diminiſhes, which cauſes inundations to continue for ſeveral days; for when even a leſs quantity of water comes after the overflowing than before, the inundation will ſtill be made, becauſe it depends much more on the velocity of the water than on the quantity ; if it was not ſo rivers would overflow for an hour or two and then return to their beds, which never occurs ; the inundations always remaining for ſeveral days ; whether the rain ceaſes or a leſs quantity of water is brought, becauſe the overflowing has diminiſhed the velocity, and conſequently, although the like quantity of water is no longer carried in the ſame time as before, yet the effects are the ſame as if the greater quantity had come there. It might be remarked on the occaſion of this diminution, that if a conſtant wind blows againſt the current of the river, the inundation will be much greater than it would have been without this accidental cauſe, which diminiſhes the celerity of the water ;

water; on the contrary, if the wind blows in the ſame direction with the current, the inundation will be much leſs and will more ſpeedily decline.

"The ſwelling of the Nile, ſays M. Granger, and its inundations has a long time employed the learned; moſt of them have looked upon it as marvellous, although nothing can be more natural, and is every day to be ſeen in every country throughout the world. It is the rains which fall in Abyſſinia and Ethiopia which cauſe the ſwelling and inundation of that river, though the north wind muſt be regarded as the principal cauſe. 1. Becauſe the north wind drives the clouds which contain this rain into Abyſſinia. 2. Becauſe blowing againſt the mouths of the Nile it cauſes the waters to return againſt the ſtream, and thus prevents them from running out in any great quantity: this circumſtance may be every ſeaſon obſerved, for when the wind, being at the north, ſuddenly veers to the ſouth, the Nile loſes in one day more than it gathers in four."

Inundations are generally greateſt in the upper part of rivers, becauſe the velocity of a river continues always increaſing until it arrive at the ſea, for the reaſons we have related.

Father Caſtelli, who has written very ſenſibly on this ſubject, remarks, that the height of the banks made to confine the Po from overflowing diminiſhes as they advance towards the ſea; ſo that at Ferrara, which is 50 or 60 miles from the ſea, they are near 20 feet high, above the common ſurface of the Po, but that at 10 or 12 miles from it they are not above 12 feet, although the channel of the river is as narrow there as at Ferrara *.

On the whole, the theory of the motion of running waters is ſtill ſubject to many difficulties, nor is it eaſy to lay down rules which might be applied to every particular caſe. Experience is here more uſeful than ſpeculation. We muſt not only know the general effects of rivers, but we muſt alſo know in particular the river we have to do with, if we would reaſon juſtly, make uſeful obſervations, and draw ſtable concluſions. The remarks I have above given are moſtly new; it is to be wiſhed that others may be collected, and then poſſibly in time we may obtain a ſufficient knowledge of the ſubject to lay down certain rules to confine and direct rivers, and prevent the ruin of

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* See Racolta d'autori che trattano del motto dell' acque, vol. 1, page 123.

of bridges, banks, and other damages, which the violent impetuoſity of the water occaſions.

The greateſt rivers in Europe are the Wolga, which is about 650 leagues in its courſe from Reſchow to Aſtracan, on the Caſpian ſea ; the Danube, whoſe courſe is about 450 leagues from the mountains of Switzerland to the Black Sea ; the Don, which is 400 leagues in its courſe from the ſource of the Soſnia, which it receives, to its mouth in the Black Sea ; the Dnieper, whoſe courſe is about 350 leagues, and which alſo runs into the Black Sea ; the Duine is about 400 leagues in its courſe, and empties itſelf into the White Sea, &c.

The greateſt rivers in Aſia are the Hoanho of China, whoſe courſe is 850 leagues, taking its ſource at Raja-Ribron, and falls into the ſea of China, in the middle of the gulph Changi ; the Jeſnica of Tartary, which is about 800 leagues in extent, from the lake Selinga to the northern Sea of Tartary ; the river Oby, which is about 600 leagues from Lake Kila, to the Northern Sea, beyond the Strait of Waigats ; the river Amour, of eaſtern Tartary, which is about 575 leagues in its courſe, reckoning it from the ſource of the river Kerlon, to the Sea of Kamtſchatka; the river Menan, whoſe mouth is at Poulo Condor, may be meaſured from the ſource of the Longmu which falls into it; the Kian, whoſe courſe is about 550 leagues from the ſource of the river Kinxa, which it receives, to its mouth in the China Sea; the Ganges is alſo about 550 leagues, and the Euphrates 500, taking it from the ſource of Irma, which it receives; the Indus about 400 leagues, and which falls into the Arabian Sea, on the eaſt of Guzarat; the Sirderious, which is about 400 leagues long, and falls into Lake Aral.

The greateſt rivers in Africa are Senegal, which is 1125 leagues long, comprehending the Niger, which in fact is a continuation of it, and the ſource of Gombarou, which falls into the Niger; the Nile, 970 leagues long, and which derives its ſource in Upper Ethiopia, where it makes many windings; there are alſo the Zaira, the Coanza, and the Couma, which are known as far as 400 leagues, but extend much farther; the Quilmanci, whoſe courſe is 400 leagues, and which derives its ſource in the kingdom of Gingiro.

The greateſt rivers of America, and which are alſo the greateſt in the world, are the river Amazons, whoſe courſe is 1200 leagues, if we go up as far as the Lake near Guanuco, 30 leagues from Lima, where the Marãgnon takes its ſource; and even reckoning from the ſource of the river Napo, ſome diſtance from Quito, the courſe of the river Amazons is more than a thouſand leagues.

It might be ſaid that the courſe of the river St. Lawrence, in Canada, is more than 900 leagues from its mouth to the lake Ontario, from thence to lake Huron, afterwards to the lake Alemipigo, and to the lake Aſſiniboils; the waters of theſe lakes falling one into another, and at laſt into St. Lawrence.

The river Miſſiſſippi more than 700 leagues long from its mouth to any of its ſources, which are not remote from the lake of the Aſſiniboils.

The river de la Plata is more than 800 leagues long, from the ſource of the river Parana, which it receives.

The river Oroonoko runs more than 575 leagues, reckoning from the ſource of the river Caketa, near Paſto, part of which falls into the Oroonoko, and part flows alſo towards the river Amazons.

The river Madera, which falls into the Amazons, is more than 660 leagues.

To know nearly the quantity of water the ſea receives by all the rivers which fall into it, let us ſuppoſe that one half of the globe is covered by the ſea, and that the other half is land, which is nearly the fact; let us ſuppoſe alſo, that the mediate depth of the ſea is 230 fathoms. The ſurface of all the earth being 170,981,012 ſquare miles; and that of the ſea 85,490,506 ſquare miles, which being multiplied by $\frac{1}{4}$, the depth of the ſea gives 21,372,626 cubical miles for the quantity of water contained in the ocean. Now to calculate the quantity of water which the ocean receives from the rivers, let us take ſome great river, whoſe rapidity and quantity of waters are known; for example, the Po, which runs through Lombardy, and waters a track of land 380 miles long; according to Riccioli, its breadth, before it divides into many trenches, is 100 perches of Boulogne, or 1000 feet, its depth 10 feet, and it runs four miles an hour; therefore the Po ſupplies the ſea with 200,000 cubical perches of water in an hour, or 4 millions 800 thouſand in a day; but a cubical mile contains 125 millions cubical perches; therefore 26 days is required to convey a cubical mile of water to the ſea: it remains therefore only to determine the proportion between the river Po, and all the rivers of the earth taken together, which is impoſſible to do preciſely. But to know it pretty exactly, let us ſuppoſe that the quantity of water which the ſea receives by the large rivers in all countries is proportional to the extent and ſurface of theſe countries, and that conſequently the country watered by the Po, and other rivers which fall therein, is in the ſame proportion on the ſurface of the whole earth, as the Po is to all the rivers of the earth. Now by the moſt correct charts, the Po, from its ſource to its mouth, traverſes a tract 380 miles long, and the rivers which fall therein, on each ſide, proceed from the ſprings and rivers 60 miles diſtant from the Po, therefore this great river, and the others it receives, waters a tract 380 miles long, and 120 miles broad, which makes 450,600 ſquare miles, but the ſurface of all the dry land is 85,490,506 ſquare miles; conſequently all the water which the rivers carry to the ſea, will be 1974 times greater than the quantity which the Po furniſhes; but as 26 rivers equal to the Po, furniſhes a cubical mile of water to the ſea in a day, of courſe 1874 rivers like the Po, would ſupply the ſea with 26,308 cubical miles of water in a year, and that in the ſpace of 812 years all the rivers would ſupply the ſea with 21,372,626 cubical miles of water; that is to ſay, as much as there is in the ocean, and therefore 812 years is only required to fill it *.

The reſult of this calculation is, that the quantity of water evaporated from the ſea, and which the winds convey on the earth, is about 245 lines, or from 20 to 21 inches a year, or about two thirds of a line each day; this is a very trifling evaporation even when trebled, in order to eſtimate the water which refalls in the ſea, and which is not conveyed over the earth. Mr. Halley, in the Phil. Tranſactions, page 192, evidently ſhews, that the vapours which riſe above the ſea, and which the winds convey over all the earth, are ſufficient to ſupply all the rivers in the world.

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* See Keil's Examination of Burnet's Theory, page 126.

Next to the Nile the river Jordan is the moſt conſiderable in the Levant, or even in Barbary; it ſupplies the Dead Sea with about ſix million tons of water every day; all this water, and more, is raiſed by evaporation; for, according to Halley's calculation of 6914 tons evaporated from each mile, the Dead Sea, which is 72 miles in length by 18 broad, muſt every day loſe near nine million tons of water, that is, not only all the water it receives from the river Jordan, but alſo that of the ſmall rivers which come into it from the mountains of Moab and elſewhere; conſequently there is no neceſſity for its communicating with any other ſea by ſubterraneous canals*.

The moſt rapid rivers are the Tigris, the Indus, the Danube, the Yrtis, in Siberia, the Malmiſtra, in Sileſia, &c. but as we have already obſerved, the proportion of the rapidity of rivers depends upon the declivity and upon the weight and quantity of water; by examining the globe, we ſhall find, that the Danube is much leſs inclined than the Po, the Rhine, or the Rhone, for the Danube has a much longer courſe than any of theſe other rivers, and falls into the Black Sea, which is higher than the Mediter-

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* See Shaw's Travels, vol. II. page 71.

Mediterranean, and perhaps more ſo than the ocean.

All large rivers receive many others in the extent of their courſe; for example, the Danube receives more than 200 rivulets and rivers; but by reckoning only ſuch as are conſiderable rivers, we ſhall find that the Danube receives 31, the Wolga 32, the Don 5 or 6, the Nieper 19 or 20, the Duine 11 or 12; ſo likewiſe in Aſia the Hoanho receives 34 or 35, the Jeniſca 60, the Oby as many, the Amour about 40, the Kian, or river Nankin about 30, the Ganges upwards of 20, the Euphrates 10 or 11, &c. In Africa, the river Senegal receives upwards of 20 rivers: the Nile does not receive any river for upwards of 500 miles from its mouth; the laſt which falls therein is the Moraba, and from this place to its ſource it receives about 12 or 13 rivers. In America, the river Amazons receives more than 60, all of which are very conſiderable; the river St. Lawrence about 40, by reckoning thoſe which fall into the lakes; the Miſſiſſippi more than 40, the Plata more than 50, &c.

There are high countries on the earth, which ſeem to be points of diviſion marked by nature for the diſtribution of the waters. In Europe, the environs of Mount St. Goddard are one of theſe points; another is ſituate between the provinces of Belozera and Wologda, in Muſcovy, from whence many rivers deſcend, ſome of which go to the White Sea, others to the Black, and ſome to the Caſpian. In Aſia there are ſeveral, in the country of Mogul Tartary, from whence rivers flow into Nova Zembla, others to the Gulph Linchidolin, others to the ſea of Corea, others to that of China: and ſo likewiſe the Little Thibet, whoſe waters flow towards the ſea of China; the Gulph of Bengal, the Gulph of Cambay, and the Lake Aral; in America, the province of Quito; whoſe rivers run into the North and South Seas and the Gulph of Mexico.

In the old continent there are about 430 rivers, which fall directly into the ocean, or into the Mediterranean and Black Seas; but in the new continent, not more than 145 rivers are known, which fall directly into the ſea: in this number I have comprehended only the great rivers, like the Somme in Picardy.

All theſe rivers carry to the ſea a great quantity of mineral and ſaline particles, which they have waſhed from the different ſoils through which they have paſſed. The particles of ſalt, which are eaſily diſſolved, are conveyed to the ſea by the water. Some philoſophers, and among the reſt Halley, have pretended that the ſaltneſs of the ſea proceeded only from the ſalts of the earth, which the rivers tranſport therein. Others aſſert, that the ſaltneſs of the ſea is as ancient as the ſea itſelf, and that this ſalt was created that the waters might not corrupt; but we may juſtly ſuppoſe that the ſea is preſerved from corruption by the agitations produced by the winds and tides, as much as by the ſalt it contains; for when put in a barrel it corrupts in a few days, and Boyle relates that a mariner who was becalmed for 13 days, found, at the end of that time, the water ſo infected, that if the calm had not ceaſed, the greateſt part of his people would have periſhed. The water of the ſea is alſo mixed with a bituminous oil, which gives it a diſagreeable taſte, and renders it very unhealthful. The quantity of ſalt contained in ſea water is about a fortieth part, and is nearly equally ſaline throughout, at top as well as bottom, under the line, and at the Cape of Good Hope; although there are ſeveral places as off the Moſambique Coaſt, where it is ſalter than elſewhere.* It is alſo aſſerted not to be ſo ſaline under the Arctic Circle, which may proceed from the amazing quantities of ſnow, and the great rivers which fall into thoſe ſeas, and becauſe the heat of the ſun produces but little evaporation in hot climates.

Be this as it may, I conceive that the ſaltneſs of the ſea is not only cauſed by the banks of ſalt at the bottom of the ſea, and along the coaſts, but alſo by the ſalts of the earth, which the rivers continually convey therein; and that Halley had ſome reaſon to preſume that in the beginning of the world the ſea had but little or no ſaltneſs; that it is become ſo by degrees, and in proportion as the rivers have brought ſalts therein; that this ſaltneſs is every day increaſing, and that conſequently, by computing the whole quantity of ſalt, brought by all the rivers, we might attain the knowledge of the age of the world by the degrees of the ſaltneſs of the ſea.

Divers and pearl fiſhers aſſert, according to Boyle, that the deeper they deſcend into the ſea, the colder is the water; and that the cold is ſo intenſe at conſiderable depths, that they cannot remain there ſo long under water, but are obliged to come up again much ſooner than when they deſcend to only a moderate one. It appeared to me that the weight of the water might be as much the cauſe of compelling them to ſhorten their uſual time as the intenſeneſs of the cold, when they deſcend to a depth of 3 or 400 fathoms; but, in fact, divers ſcarcely ever deſcend above an hundred feet. The ſame author relates, that in a voyage to the Eaſt-Indies, beyond the line at about 35 degrees ſouth latitude, a ſounding lead of 30 or 35lb weight was ſunk to the depth of 400 fathoms, and that being pulled up again, it had become as cold as ice. It is alſo a frequent practice with mariners to cool their wine at ſea by ſinking their bottles to the depth of ſeveral fathoms, and they affirm the deeper the bottles are ſunk, the cooler is the wine.

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* See Boyle, vol. iii. page 217.

Theſe circumſtances might induce us to preſume that the ſea is ſalter at the bottom than at the ſurface; but we have teſtimonies which prove the contrary, founded on experiments made to fill veſſels with ſea water, which were not opened till they were ſunk to a certain depth, and the water was found to be no ſalter than at the ſurface. There are even ſome places where the water at the ſurface is ſalt, and that at the bottom freſh; and this muſt always be the caſe, where there are ſprings at the bottom of the ſea, as near Goo, Ormus, and even in the ſea of Naples, where there are hot ſprings at the bottom.

There are other places where ſulphurous ſprings and beds of bitumen have been diſcovered at the bottom of the ſea, and on land there are many of theſe ſprings of bitumen which run into it.

At Barbadoes there is a pure bitumen ſpring, which flows from the rocks into the ſea: ſalt and bitumen, therefore, are predominant matters in the ſea water; but it is alſo mixed with many other matters; for the taſte of water is not the ſame in every part of the ſea; beſides, the agitation and the heat of the ſun alters the natural taſte which the ſea ſhould have; and the different colours of different ſeas, at different times, prove that the waters of the ſea contain ſeveral kinds of matters, either which it looſens from its own bottom, or are brought thither by rivers.

Almoſt all countries watered by great rivers are ſubject to periodical inundations, thoſe which are low, and derive their ſources from a great diſtance, overflow the moſt regularly.

Every perſon almoſt has heard of the inundations of the Nile, which preſerves the ſweetneſs and whiteneſs of its waters, though extended over a vaſt track of country and into the ſea. Strabo and other ancient authors have written that it had ſeven mouths, but there now remains only two which are navigable; there is a third canal which deſcends to Alexandria, and fills the ciſterns there, and a fourth which is ſtill ſmaller; but as they have for a long time neglected to clean their canals, they are nearly choaked up. The ancients employed a great number of workmen and ſoldiers, and every year, after the inundation, they carried away the mud and ſand which was in theſe canals. The cauſe of the overflowing of the Nile proceeds from the rains which fall in Ethiopia. They begin in April and do not ceaſe till September; during the firſt three months, the days are ſerene and fair, but as ſoon as the ſun goes down the rains begin, nor ſtop till it riſes again, and are generally accompanied with thunder and lightning. The inundation begins in Egypt about the 17th of June, it generally increaſes during 40 days, and diminiſhes in about the ſame time; all the flat country of Egypt is overflowed; but this inundation is much leſs now than it was formerly, for Herodotus tells us, that the Nile was 100 days in ſwelling, and as many in abating: if this is true, we can only attribute the cauſe thereof to the elevation of the land, which the mud of the waters has heightened by degrees, and to the diminution of the mountains in Africa, from whence it derives its ſource. It is very natural to believe that theſe mountains have diminiſhed, becauſe the abundant rains which fall in theſe climates during half the year, ſweep away great quantities of ſand and earth from the mountains into the valleys, from whence the torrents waſh them into the Nile, which carries great part into Egypt, where it depoſits them in its overflowings.

The Nile is not the only river whoſe inundations are regular; the river Pegu is called the *Indian Nile*, becauſe it overflows regularly every year; it inundates the country for more than 30 leagues from its banks; and, like the Nile, leaves an abundance of mud, which ſo greatly fertilizes the earth, that the paſturage is excellent for cattle, and rice grows in ſuch great abundance, that every year a number of veſſels are laden with it, without leaving a ſcarcity in the country*. The Niger, or what amounts

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* See Ovington's Travels, vol. ii. page 290.

amounts to the ſame, the upper part of the Senegal, likewiſe overflows and covers all the flat country of Nigritia; it begins nearly at the ſame time as the Nile, and increaſes alſo for 40 days: the river de la Plata, in Braſil, alſo overflows every year, and at the ſame time as the Nile. The Ganges, the Indus, the Euphrates, and ſome others, overflow annually; but all rivers have not periodical overflowings, and when inundations happen, it is the effect of many cauſes, which combine to ſupply a greater quantity of water than common, and, at the ſame time, to retard its velocity. We have before obſerved, that in almoſt all rivers the inclination of their beds diminiſhes towards their mouths in an almoſt inſenſible manner; but there are ſome whoſe declivity is very ſudden in ſome places, and forms what is termed a *cataract*, which is nothing more than a fall of water quicker than the common current of the river. The Rhine, for example, has two cataracts, the one at Bilefield, and the other near Schafhouſe: the Nile has many, and among the reſt two which are very violent, and fall from a great height between two mountains; the river Wologda, in Muſcovy, has alſo two near Ladoga; the Zaire, a river of Congo, begins by a very large cataract, which falls from the top of a mountain; but the moſt famous is that of Niagara, in Canada, that falls from a perpendicular height of 156 feet, like a prodigious torrent, and is more than a quarter of a mile broad: the fog, or miſt, which the water makes in falling, is perceived at five miles diſtance, and riſes as high as the clouds, forming a very beautiful rainbow when the ſun ſhines thereon. Below this cataract there are ſuch terrible whirlpools, that nothing can be navigated thereon for ſix miles diſtance, and above the cataract the river is much narrower than it is in the upper lands *. The deſcription given of it by *Father Charlevoix* is as follows:

" My firſt care, when I arrived, was to viſit the moſt beautiful caſcade that is, perhaps, in nature, but I immediately diſcovered that Baron la Hontain was deceived ſo greatly, both in its height and figure, that one might reaſonably imagine he had never ſeen it.

" It is true, that if we meaſure its height by the three mountains you are obliged to aſcend in going to it, there is not much abatement to be made of the 600 feet, which the map of M. Deliſſe

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* See Phil. Tranſ. Abr. vol. vi. part ii. page 119.

Deliſſe gives it, who doubtleſs advanced this paradox only on the credit of the Baron la Hontain and Father Honnepin; but after I arrived at the top of the third mountain, I obſerved that in the ſpace of three leagues, which I afterwards had to go to this fall of water, although you are forced ſometimes to aſcend, you muſt nevertheleſs deſcend ſtill more, and this is what travellers do not appear to have paid proper attention to. As we can only approach the caſcade on one ſide, nor ſee it but in the profile, it is not eaſy to meaſure its height by inſtruments: experiments have been made to do it by a long cord tied to a pole, and after having often attempted this manner, it was found to be only 115 or 120 feet high; but it is impoſſible to aſcertain whether the pole was not ſtopped by ſome projection of the rock, for although when drawn up again the end of the cord was always wet, yet that is no proof, ſince the water which precipitates from the mountain, flies up again in foam to a very great height: for my own part, after having conſidered it on every ſide that I could examine it to advantage, I think that we cannot allow it to be leſs than 140 or 150 feet.

" Its figure is that of an horſe-ſhoe, and its circumference is about 400 paces; but exactly in its middle, it is divided by a very narrow iſland, about half a quarter of a league long. It is true theſe two parts join again; that which was on my ſide, and of which I could only have a ſide view, has ſeveral projecting points, but that which I beheld in front, appeared to be perfectly even." The Baron has alſo mentioned a torrent, which, if not the offspring of his own invention, muſt fall into ſome channel upon the melting of the ſnow.

There is another cataract, three miles from Albany, in the province of New-York, whoſe height is 50 feet perpendicular, and from which there ariſes a miſt that occaſions a faint rainbow *.

In all countries where mankind are not ſufficiently numerous to form poliſhed ſocieties, the ground is more irregular, and the beds of rivers more extended, leſs equal, and often abound with cataracts. Many ages were required to render the Rhone and the Loire navigable. It is by confining waters, by directing their courſe, and by cleanſing the bottom of rivers, that they obtain a fixed and regular courſe; in all countries thinly inhabited Nature is rude, and often deformed.

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* Phil. Tranſ. vol. vi. part ii. page 19.

There are rivers which loſe themſelves in the ſands, and others which ſeem to precipitate into the bowels of the earth: the Guadalquiver in Spain, the river Gottenburg in Sweden, and the Rhine itſelf loſe themſelves in the earth. It is aſſerted, that in the weſt part of the iſland of St. Domingo there is a mountain of a conſiderable height, at the foot of which are many caverns, into which the rivers and rivulets fall with ſo much noiſe, as to be heard at the diſtance of ſeven or eight leagues *.

The number of rivers which loſe themſelves in the earth is very few, and there is no appearance that they deſcend very low; it is more probable that they loſe themſelves, like the Rhine, by dividing among the quantity of ſand; this is very common to ſmall rivers that run through dry and ſandy ſoils, of which we have ſeveral examples in Africa, Perſia, Arabia, &c.

The rivers of the north tranſport into the ſea prodigious quantities of ice, which, accumulating, form thoſe enormous maſſes ſo deſtructive to mariners. Theſe maſſes are the moſt abundant in the Strait of Waigat, which is entirely frozen over the greateſt part of the year, and

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* See Varenii Geograph. gen. page 43.

and are formed by the great flakes which the river Oby almoſt continually brings there; they attach themſelves along the coaſts, and heap up to a conſiderable height on both ſides, but the middle of the ſtrait is the laſt part which freezes, and where the ice is the loweſt. When the wind ceaſes to blow from the North, and comes in the direction of the Strait, the ice begins to thaw and break in the middle; afterwards it looſens from the ſides in great maſſes, which are carried into the high ſea. The wind, which all winter blows from the north over the frozen countries of Nova Zembla, renders the country watered by the Oby, and all Siberia, ſo cold, that even at Toboliki, which is in the 57th degree, there are no fruit trees, while at Sweden, Stockholm, and even in higher latitudes, there are both fruit trees and pulſe. This difference does not proceed, as it has been thought, from the ſea of Lapland being warmer than the Straits; nor from the land of Nova Zembla being colder than Lapland, but ſolely from the Baltic, and the Gulph of Bothnia, tempering the rigour of the north winds, whereas in Siberia there is nothing that can temperate the cold. It is a fact, founded on experience, that it is never ſo cold on the ſea coaſts as in the inland parts of a country. There are plants which ſtand the winter in London expoſed to the open air, that cannot be preſerved at Paris; and Siberia, which is a vaſt continent, is for this reaſon colder than Sweden, which is ſurrounded on all ſides by the ſea.

The coldeſt country in the world is Spitzbergen: it lies in the 78th degree of north latitude, and is entirely formed of ſmall peaked mountains; theſe mountains are compoſed of gravel, and flat ſtones ſomewhat like ſlate, heaped one on the other; which, it is affirmed by navigators, are raiſed by the wind, and increaſe ſo quick, that new ones are diſcovered every year. The rein-deer is the only animal ſeen here, which feeds on a ſhort graſs and moſs. On the top of theſe little mountains, and at more than a mile from the ſea, the maſt of a ſhip was found with a pulley faſtened to one of its ends, which gives room to ſuppoſe that the ſea once covered the tops of theſe mountains, and that this country is but of modern date; it is uninhabited, and uninhabitable; the ſoil of theſe ſmall mountains has no conſiſtence, but is looſe, and ſo cold and penetrating a vapour ſtrikes from it, that it is impoſſible to remain any length of time thereon.

The veſſels which go to Spitzbergen for the whale fiſhery, arrive there early in the month of July, and take their departure from it about the 15th of Auguſt, the ice preventing them from entering the ſea earlier, or quitting it after. Prodigious pieces of ice, 60, 70, and 80 fathoms thick are ſeen there, and there are ſome parts of it where the ſea appears frozen to the very bottom*: this ice, which is ſo high above the level of the ſea, is as clear and tranſparent as glaſs.

There is alſo much ice in the ſeas of North America, as in Aſcenſion Bay, in the Straits of Hudſon, Cumberland, Davis, Forbiſhers, &c. Robert Lade aſſerts that the mountains of Friezeland are entirely covered with ſnow, and its coaſts with ice, like a bulwark, which prevents any approaching them. " It is, ſays he, very remarkable that in this ſea we meet with iſlands of ice more than half a mile round, extremely high, and 70 or 80 fathoms deep; this ice, which is ſweet, is perhaps formed in the rivers or ſtraits of the neighbouring lands,

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* In contradiction to this idea it is now a generally received opinion, that the mountains of ice in the North and South Seas are exactly the ſame depth under as they are heighth above the ſurface of the water.

&c. Theſe iſlands or mountains of ice are ſo moveable, that in ſtormy weather they follow the track of a ſhip as if they were drawn along in the ſame furrow by a rope. There are ſome of them tower ſo high above the water, as to ſurpaſs the tops of the maſts of the largeſt veſſels *."

In the collection of voyages made for the ſervice of the Dutch Eaſt India Company, we meet with the following account of the ice at Nova Zembla :—" At Cape Trooſt the weather was ſo foggy as to oblige us to moor the veſſel to a mountain of ice, which was 36 fathoms deep in the water, and about 16 fathoms out of it.

" On the 10th of Auguſt the ice dividing, it began to float, and then we obſerved that the large piece of ice, to which the ſhip had been moored, touched the bottom, as all the others paſſing by ſtruck againſt without moving it. We then began to fear being incloſed between the ice, that we ſhould either be frozen in or cruſhed to pieces, and therefore endeavoured to avoid the danger by attempting to get into another latitude, in doing of which the veſſel was forced through the floating ice, which made a tremendous

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* See the Voyages of Lade, vol. 11. page 305, &c.

mendous noiſe, and ſeemingly to a great diſtance; at length we moored to another mountain for the purpoſe of remaining there that night.

" During the firſt watch the ice began to ſplit with an inexpreſſible noiſe, and the ſhip keeping to the current, in which the ice was now floating, we were obliged to cut the cable to avoid it; we reckoned more than 400 large mountains of ice, which were 10 fathoms under and appeared more than 2 fathoms above water.

" We afterwards moored the veſſel to another mountain of ice, which reached above 6 fathoms under water. As ſoon as we were fixed we perceived another piece beyond us, which terminated in a point and went to the bottom of the ſea; we advanced towards it, and found it 20 fathoms under water, and near 12 above the ſurface.

" The 11th we reached another large ſhelve of ice, 18 fathoms under water, and 10 above it.

" The 21ſt, the Dutch got pretty far in among the ice, and remained there the whole night; the next morning they moored their veſſel to a large bank of ice which they aſcended, and conſidered as a very ſingular phenomenon, that its top was covered with earth, and they found near 40 eggs thereon. The colour was not the common colour of ice, but a fine ſky blue. Thoſe who were on it had various conjectures from this circumſtance, ſome contending it was an effect of the ice, while others maintained it to be a maſs of frozen earth. It was about eighteen fathoms under water, and 10 above *."

Wafer relates, that near Terra del Fuega he met with many high floating pieces of ice, which he at firſt miſtook for iſlands. Some appeared a mile or two in length, and the largeſt not leſs than 4 or 500 feet above the water.

All this ice, as I have obſerved in the 6th article, was brought thither by the rivers ; the ice in the ſea of Nova Zembla, and the Straits of Waigat come from the Oby, and perhaps from Jeniſca, and other great rivers of Siberia and Tartary ; that in Hudſon's Straits, from Aſcenſion Bay, into which many of the North American rivers fall ; that of Terra del Fuega from the ſouthern continent. If there are leſs on the North coaſts of Lapland, than on thoſe of Siberia and the Straits of Waigat, it is becauſe all

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* Voyage of the Dutch to the North, vol. 1, 3, page 49.

all the rivers of Lapland fall into the Gulph of Bothnia, and none go into the northern ſea. The ice may alſo be formed in the ſtraits, where the tides ſwell much higher than in the open ſea, and where conſequently the ice, which is at the ſurface, may heap up and form thoſe mountains which are ſeveral fathoms high; but with reſpect to thoſe which are 4 or 500 feet high, they appear to be formed on high coaſts, and I imagine that when the ſnow, which covers the tops of theſe coaſts melts, the water flows on the flakes of ice, and being frozen thereon, thus increaſes the ſize of the firſt until it comes to that amazing height. That afterwards in a warm ſummer, theſe hills of ice looſen from the coaſts by the action of the wind and motion of the ſea, or perhaps even by their own weight, and are driven as the wind directs, ſo that they at length may arrive into temperate climates before they are entirely melted.

END OF THE FIRST VOLUME.